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MEASUREMENT OF TOBACCO SMOKE COMPONENTS IN HUMAN SUBJECTS

report to

NATIONAL CANCER INSTITUTE

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I. SUMMARY

I. SUMMARY

The purpose of this study was to determine a suitable method(s) for estimating smoke intake in the human smoking population, both in an experimental setting and eventually in a survey-type situation. Although there have been studies in the past to determine smoke intake by analysis of various smoke components in body fluids, to our knowledge this is the first attempt to assemble in a single document much of the relevant knowledge available from the literature and other sources, including consultants.

Early in the study inquiries were made of various expert consultants for advice and suggestions relating to compounds or methods suitable for measuring smoke intake. It became clear that, although this approach was necessary for specific segments of the problem, it was inappropriate and inefficient for the ultimate objective since individual experts lacked essential information outside of their area of expertise. We have attempted to bring these various types of information together so that this report might provide scientists of diverse backgrounds with a broad perspective, which together with various clues and other facts may catalyze thinking about novel approaches to the measurement of smoke intake, in addition to those specifically proposed.

To this general end the report presents a compilation of:

(1) Over 475 compounds reported in smoke, their amount and methods of analysis.

(2) Over 20 compounds found in smoke which were previously reported in the literature to measure smoke intake, related information on the body fluid used, methods of analysis, and where stated or derivable, the reliability and limitations of the methodology.

(3) Various biological responses, to whole smoke or to individual smoke components, which conceivably could be used as indicators of smoke intake.

(4) The factors which influence the determination of smoke intake, e.g., level of smoke retention in body fluids, volume and availability of various body fluids, the degree of invasiveness needed for sampling, and pharmacokinetics of the marker compound once inhaled and absorbed.

(5) Analytical procedures surveyed for the state-of-the-art, to optimize selection of appropriate methodology based on sensitivity, specificity and reproducibility. This effort has included not only commercially available instrumentation but also specialized research instrumentation used in a few research laboratories.

Our own analysis of the situation has led us to a recommendation that for the immediate future, two methodologies should be further developed for experimental studies. Since they involve the use of stable isotopes, in carbon monoxide and water, they might well not be suitable for survey studies but could provide a firm basis for calibration of survey methods with other compounds. Our reasoning leading to this recommendation is based on the following considerations.

(1) A great many compounds are present in smoke in sufficient quantity to be useful as indicators for estimating smoke intake. In most instances, however, the amount of information available about the distribution, metabolism and elimination of these compounds was inadequate to permit an evaluation.

(2) None of the biological responses examined appear to be sufficiently specific or attainable by ordinary sampling techniques to be considered prime candidates for determining smoke intake.

(3) An in depth analysis of previous studies determined various sources of error and uncertainty. The major ones include: the inability of the investigator to control adequately the volume of smoke generated from each cigarette by the smoker; the inability to determine the fraction of generated smoke actually inhaled; the pharmacokinetics of the compound of interest, e.g., transfer rate from lung to body fluid; and finally, in many cases, changes in background levels of the marker compounds in body fluid, i.e., from endogenous and exogenous sources. These appear to be the major obstacles in any future studies on the development of methodology for estimating smoke intake quantitatively.

(4) Compounds that have been reported in the literature as indicators of smoke intake include nicotine, cotinine (metabolite of nicotine), thiocyanate (cyanide metabolite), free cyanide, polonium 210, lead 210, thorium 228, bromine 82, cadmium, nitrogen, carbon monoxide, acetonitrile, and 1,2,3,4-dibenzopyrene. Although body tissue levels of many of the above compounds have been shown to be increased in smokers, the degree of correlation between smoking history and level of these compounds in a body fluid, with the exception of carbon monoxide

and acetonitrile, has not been impressive. Additional study is needed to confirm the high correlations found using acetonitrile.

Results of this study lead us to recommend further investigations of the potential applicability of carbon monoxide as an indicator of gas phase intake, particularly in the light of the extent of knowledge of its biochemical properties. Water, as a constituent of both particulate and gas phase of smoke, may also be useful as an indicator. However, in view of the presence in the body fluids of carbon monoxide and water from endogenous and exogenous sources other than cigarette smoke, it will be necessary to use a suitable method of tagging the compound in smoke. Use of the stable mass isotopes was selected since they provide a high degree of selectivity and instrumentation is available to maximize sensitivity.

The following subsidiary recommendations offer a logical development of this general recommendation, leading to methods for direct use in experimental situations, and providing a basis for development of survey methods.

(1) To help differentiate the source of the marker compound in body fluid, i.e., to limit it to cigarette smoke versus other sources, a mass-isotope added to cigarette tobacco is recommended. Although many compounds are potentially good indicators of smoke intake, carbon monoxide and water are two which, if labeled with a mass-isotope (^{13}C, ^{2}D), show the most promise of offering this differentiation.

(2) The use of ^{13}carbon monoxide is recommended since it provides a non-invasive method and a measure of the amount of smoke (gas phase) actually inhaled. Also the level of tissue absorption and metabolism which complicate many quantitative studies of smoke intake is minimal. For analysis, our recomendation is the use of diode laser spectroscopy. This instrumentation provides a maximum in sensitivity and specificity. The suggested instrumentation is still a research tool and not available in most analytical laboratories, yet it is, in our best judgment, the most promising for providing methodology for determing smoke intake quantitation. The preparation of a compound containing ^{13}C or ^{2}D suitable for labeling tobacco which would produce labeled carbon monoxide or water, respectively, upon combustion should not involve major expenditure. We have considered several possible ways of labeling cigarettes, but the selection should not be considered final.

(3) Cigarette smoking should be carried out with a calibrated smoking machine to control the amount of smoke generated and the level of the marker compound in mainstream smoke. In biological experiments, all smoke in exhaled breath (plus any which may be recovered from the mouth) should be collected to establish the amount not retained in the respiratory tract.

(4) In a pilot study, smoke intake would be determined under standardized and well controlled exposure conditions using the tracheotomized dog initially, then a selected population of chronic smokers. Carbon monoxide would be the first compound to be evaluated.

(5) Once a protocol for quantitatively estimating smoke intake using mass-isotope techniques is developed, other potential natural marker compounds can be calibrated for use in characterizing the intake of smoking populations involving large numbers of subjects.

(6) Cigarette butts could be analyzed for different smoking modes to determine if there are differences in the build-up of various smoke components. These differences would serve as a crude measure of the degree of puffing versus smoldering of the cigarette.

Until such studies are actually carried out, an assessment of overall program cost is difficult to make. Analysis of trace gases by laser spectroscopy (as proposed in Section V and detailed in Section VI) for the detection of ^{13}C-carbon monoxide in expired air, will require a considerable initial capital outlay. The diode laser source assembly will cost approximately $16,000 with additional components (which would be needed for any laser) costing another $50,000. In terms of epidemiological studies of smoking, the cost of the proposed capital equipment would probably be small in relation to the total number of samples needed to characterize various segments of the smoking population.

II. INTRODUCTION

II. INTRODUCTION

The consequences of cigarette smoking on health have been reviewed in reports for the Surgeon General of the United States in 1964, 1968 and 1971. Based in large part on epidemiological studies, these reports conclude that there is a close statistical association between cigarette consumption and a variety of human diseases, notably lung cancer, chronic pulmonary disease and cardiovascular disease. A major problem in these epidemiological studies correlating cigarette smoking with systemic effects experienced by man, be they either irreversible disease states or transient impairment of physiological function, was a lack of quantitative assessment of actual smoke intake and retention.

For obvious reasons the rate of puffing, puff volume, depth of inhalation, time elapsed for smoke in the lung (time between smoke inhalation and exhalation), and many other factors -- all profoundly influence the overall retention of smoke components and are not accounted for in estimating dose or smoking history by inquiry or questionnaire.

Since smoke is composed of hundreds of different chemical compounds, reliable measurements of smoke intake are dependent on the proper selection of one (or more) component that is transferred from smoke to a physiological fluid (or, in the broader sense, body tissues) in a very reproducible manner during smoking. Moreover, the fate of a suitable compound must be well understood in terms of its distribution, metabolism and excretion, as well as those factors that would tend to influence its stability in the smoke. Finally, the practical aspects of body fluid analysis, e.g., sensitivity, specificity, cost of analysis, and a use of non-invasive methodology to acquire tissue fluids, have helped shape the conclusions of this report.

To clarify the problems of quantitating smoke intake in human subjects, selected experts in related fields have been consulted and have provided considerable direction, especially in areas of analytical instrumentation. A literature search was used to define relevant knowledge from past research.

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III. LITERATURE SURVEY

III. LITERATURE SURVEY

A. SOURCES

Due to the extensive literature related to the biology and chemistry of cigarette smoke, in part our efforts have been directed toward compilation of a list of those chemical compounds which occur in smoke in sufficient quantities so that they would be present in measurable levels in body fluids using existing published methodology. To accomplish this it was necessary to compile from the published literature a list of chemical compounds reported in cigarette smoke, the amount, and the methods of analysis.

In addition to an extensive compilation of literature in the ADL files the following sources were also searched: Chemical Abstracts (1/1960-6/1974); Biological Abstracts (1/1967-6/1973); Index Medicus (1/1960-6/1973); the Reports of the Surgeon General on the Health Consequences of Smoking (1964, 1968, 1971); and The Bibliography on Smoking and Health, National Clearinghouse for Smoking and Health, HEW (1/1968-6/1973). We have consulted with the editor of The Bibliography on Smoking and Health and with the Assistant Director for Information Services of NERAC computerized data service at the University of Connecticut, Storrs, Connecticut. A computerized literature search was also carried out through the National Library of Medicine in both the MEDLINE and the MEDLARS programs, and also the Preston Technical Abstract Service.

The MEDLINE search (1970-3/1974) produced 578 citations under the following key words: *complications of smoking* (276 citations); *carbon monoxide/blood or carbon monoxide/urine or carbon monoxide/analysis* (251 citations); *carbon monoxide and breath tests* (no citations); *carbon monoxide and blood gas analysis* (13 citations); *nicotine/blood* (11 citations); *dose-response relationship, smoke* (14 citations); and *smoking/pathology* (13 citations).

The MEDLARS search (1/1964-5/1973) furnished 873 citations under the following key words: *smoking and blood, smoking and urine, smoking and lymph, smoking and hemolymph, smoking and plasma* (693 citations); *smoking and other body fluids* (180 citations).

The Preston Technical Abstract Search (1960-1971) produced 84 citations (key word: *cigarette smoke*).

Certain operational problems associated with the literature search soon became apparent, particularly with respect to the computerized aspects of the literature search. All of the computerized data retrieval systems were categorized and classified under certain key words. Due to the enormous volume of smoke related papers in the literature, plus the broad scope of our inquiry which overlapped into several areas, the available key words were not specific enough for our purposes. Since we could not coordinate the key words programmed into the computer with

our particular needs, we requested, by necessity, several key words to ensure receiving all citations relevant to smoke intake analysis. This action resulted in many citations unrelated to our specific aims. For example, citations under smoking and health might include papers concerned with various disease states which coincidentally made mention of the smoking history of the individual(s), or perhaps papers concerned with the effects of marijuana smoking, etc.

To deal effectively with all the published literature, it was necessary to have many foreign publications translated into English.

To assist the reader, a list of frequently used abbreviations for the method of analysis is included.

LIST OF ABBREVIATIONS FREQUENTLY USED IN REFERRING TO METHODS OF ANALYSIS

GC	Gas Chromatography
GCFPD	Gas Chromatography with Flame Photometric Detector
GCFID	Gas Chromatography with Flame Ionization Detector
GCTCD	Gas Chromatography with Thermal Conductivity Detector
GCECD	Gas Chromatography with Electron Capture Detector
MS	Mass Spectroscopy
GLC	Gas-Liquid Chromatography
UV	Ultraviolet Spectroscopy
IR	Infrared Analysis
SPF	Spectrophotometric
C	Colorimetric
NAA	Neutron Activation Analysis
FS	Fluorescence Spectroscopy
AAS	Atomic Absorption Spectroscopy
CC	Column Chromatography
PC	Paper Chromatography
CLUM	Chemiluminescence
A	Analytical Methods
POT	Potentiometric Analysis
GRAV	Gravimetric Method
TLC	Thin Layer Chromatography
HRCC	High Resolution Capillary Columns
RIA	Radioimmunoassay
ESR	Electron Spin Resonance
SCIN	Scintillation Analysis
FP	Freezing Point
MP	Melting Point
SSMS	Spark Source Mass Spectroscopy
FLP	Flame Photometry
NMG	No Method Given

B. COMPOUNDS IN SMOKE REPORTED IN BIOLOGICAL FLUIDS

The bulk of previous studies to estimate smoke intake has focused on measuring nicotine, thiocyanate, or carbon monoxide in either blood, urine, saliva or expired air. Here we would like to focus on some of the complications in published procedures.

Various methods have been used to determine the concentration of nicotine in an individual who smokes and these studies have shown that nicotine is rapidly metabolized and the molecule is rather unstable in neutral and alkaline solutions, undergoing a variety of chemical changes. These factors have probably contributed to the great variability in the results of nicotine, and its metabolite cotinine, determination in urine. This has been demonstrated by Becket[38], who artificially maintained the urine at an acidic pH by the administration of ammonium chloride tablets to the test subjects. Another metabolite, nicotine-1'-oxide is independent of urinary pH but the amount present is small (Beckett[38]).

Urinary nicotine analysis often requires a 24-hour sample and tedious extraction and assay procedures (Beckett[38,39]), (Bowman[63]) (Booth[60]) (Dagne[124]). Moreover, sex dependent changes in excretion (Becket[39]) must also be taken into account; and smoking is believed to induce enzymes that alter the metabolism of nicotine (Beckett[41]). When both smokers and non-smokers were administered intravenously identical doses of nicotine, smokers excreted lower levels of nicotine, although levels of cotinine were comparable in both groups. This finding would lead one to question the use of urinary nicotine as a measure of smoke intake. Blood nicotine analyses, in general, provide more reliable data on body burden than do analyses of urinary nicotine excretion (Schievelbein[474]) (Isaac[237]).

Nicotine is rapidly eliminated from the bloodstream e.g., 30 seconds (Isaac[236])], and within a few minutes the concentration drops below the levels of gas chromatographic detectability (Isaac[236]) (Schievelbein[474]). Also, the rate of plasma decline shows a considerable degree of variability between smokers (Isaac[237]). Langone, Gjika and Van Vunakis[286] have recently developed a highly sensitive radioimmunoassay procedure for detecting nicotine and/or cotinine either in blood or urine. However, they report no apparent correlation between the number of cigarettes smoked and the concentrations of nicotine and cotinine in body fluids when using their procedure, although within each subject there is a well defined decrease in concentration with time after smoking.

A list of compounds found in smoke which have been isolated from one or more of the body fluids is presented in Table 1. Other compounds in addition to nicotine, carbon monoxide and thiocyanate reported in body fluids include polonium-210, lead (also 210), thorium-228, cadmium, nitrogen, methanol, furfural, acetonitrile, 3,4-benzpyrene, and bis(*p*-chlorophenyl) acetic acid.

ABBREVIATIONS USED IN TABLE 1

↑	Increases, higher
↓	Decreases, lower
→	Leads to, causes
COHb	Carboxyhemoglobin
BUN	Blood urea nitrogen
SGOT	Serum glutamic oxalic transaminase
SGPT	Serum glutamic pyruvic transaminase
LDH	Lactic dehydrogenase
HR	Heart rate
BP	Blood pressure
NEFA	Non-esterified fatty acid
FFA	Free fatty acid
FA	Fatty acid
5-HT	5-Hydroxytryptamine
NE	Norepinephrine
EPI	Epinephrine
5-HIAA	5-Hydroxy-3-indole acetic acid
ADP	Adenosine diphosphate
FEV	Forced expiratory volume
SV	Stroke volume
ADH	Antidiuretic hormone
OHCS	Hydroxycorticosteroids
KA units	King Armstrong units
pCi	pico Curies

TABLE 1

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
Nicotine-1'-oxide	Booth (60)	PC	Urine (Man)	0.04 µg/ml/cig. (dextrorotatory) 0.004 µg/ml/cig. (levorotatory)
Nicotine (1 mg IV)	Beckett (38)	GLC	Urine (Man)	µg/24 hrs. pH dependent recovery: Nicotine 350; Cotinine 178; Nicotine 1-N-oxide 39
Nicotine (In Atmosphere) (15-35 µg/m^3)	Cano (83)	GC	Urine (Man)	Excretion of 22-70 µg/hr.
Nicotine (3 mg p.o.) (Cotinine)	Bowman (63)	PC	Urine (Man)	10% of administered nicotine excreted as cotinine.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings	
^{3}H-Nicotine (100 µg/kg IV)	Tsujimoto (528)	SCIN	Saliva (Dog)	Nicotine	0.15 µg/ml max. at 2 min.
				Metabolites	0.05 µg/ml at 1 hr.
			Saliva (Monkey)	Nicotine	0.08 µg/ml max. at 2 min.
				Metabolites	0.15 µg/ml max. at 5 min.
				Metabolites	0.09 µg/ml at 1 hr.
Nicotine	Schievelbein (474)	GLC	Blood 10 min. after 1 cig. (Man)	0.005-0.064 µg/ml.	
Nicotine	Langone (286)	RIA	Blood from chronic smokers (Man)	No good correlation between smoking history and nicotine blood levels.	
Hydroxycotinine	Dagne (124)	MS	Urine (Man)	Compound has been qualitatively identified in urine of smokers.	

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
Cotinine	Langone (286)	RIA	Blood from chronic smokers (Man)	No good correlation between smoking history and cotinine blood levels.
Nicotine	Isaac (237)	GLCFID	Plasma (Man)	Max. 0.05 µg/ml 1/2 hr after 1 cigarette. Average 0.01 µg/ml 1 hr after 1 cigarette.
Nicotine (Smoke)	Isaac (236)	GLC	Brachial artery blood (Dog)	Max. 0.15-0.25 µg/ml 7-10 sec. after 1 puff.
Nicotine (28 µg/kg IV)	Isaac (236)	GLC	Brachial artery blood (Dog)	Max. 0.9 to 1.3 µg/ml 25 sec. after dose, then falls rapidly.
Nicotine (Smoke or IV)	Beckett (41)	GLC	Urine (Man) (Maintained at acidic pH)	Smokers 25-50% recovery. Non-smokers 55-70% recovery.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
Nicotine (1 mg IV)	Beckett (39)	GCFID	Urine (Man)	The ratio of cotinine/nicotine excretion is higher in smokers than non-smokers, especially in females.
Nicotine	Elmenhorst (149)	SPF	Lungs (Hamster)	Correlation is shown between number of cigarettes smoked and ↑ concentration in lungs.
Nicotine (5 cigs/1 hr)	Sugitani (516)	NMG	Blood (Man)	Heavy smokers showed a noticeable ↑ in levels of blood nicotine.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings	
CO (Smoke)	Harke (202)	NMG	Blood (Man)	Smokers	3.4-10% COHb
				Non-smokers in same room with heavy smokers	1.2-2.3% COHb
CO (Smoke)	Bowden (62)	C	Blood (Man)	Smokers 9 a.m.	1.5±0.4 SD %COHb
				Smokers 4.30 p.m.	2.7±1.1 SD %COHb
				Non-smokers 9 a.m.	0.7±0.3 SD %COHb
CO (Smoke)	Cohen (107)	NMG	Blood, Expired air (Man)	(a) Good correlation between no. of cigarettes smoked and CO in expired air (r = 0.64).	
				(b) Relationship between CO in expired air and % COHb: %COHb = 0.6±0.3 (CO ppm).	

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
CO (Smoke)	Landaw (283)	IR (Expired air)	Expired air, Blood (Man)	(a) A linear correlation (r = .93) was found between CO concentration in expired air and COHb in a simultaneous venous sample of blood.
		GC (COHb)		(b) There was great variability among smokers having similar smoking habits.
CO (Smoke)	Ringold (448)	IR	Expired air, Blood (Man)	(a) Relationship between expired air CO and COHb is: $COHb\% = 0.5 + \frac{CO(ppm)}{5}$
				(b) Higher COHb levels were found in cigarette smokers than non-smokers or smokers of pipes or cigars.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
CO (Smoke)	Stewart (511)	GCFID	Expired air (Man)	(a) Smokers N=1620 %COHb 4.47±0.06 (SE)
		CO-oximeter	Blood (Man)	Non-smokers N=2798 %COHb 1.33±0.02 (SE)
				(b) Equation relating %COHb and CO ppm in expired air is: %COHb = 0.25 (CO ppm) + 0.48
				(c) Good relationship between CO levels and smoking habits up to 1.5 packs/day. Above this point there is no further appreciable increase in CO levels.
CO	Yacoub (574)	C	Blood (Man)	(a) Smokers (20 cigs/day) who did not inhale had + CO blood levels (12.1 ml) when compared to inhalers (18.8 ml/liter blood).
				(b) Both groups were > non-smokers (3.05 ml CO/liter).
				(c) Concomitant Δ in urinary SCN was seen: Non-inhalers 16.3 mg/L; Inhalers 19.4 mg/L; Non-smokers 4.5 mg/L

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
CO	Desoille (136)	IR	Blood (Man)	Smokers 0.25-1.75 ml CO/100 ml blood Non-smokers > 0.20 ml/100 ml blood
CO	Jones (248)	SPF	Blood (Man)	Smokers 5.31% COHb Non-smokers 1.55% COHb
CO	Anderhub (7)	CO-oximeter SPF	Blood (Man)	Farmworkers Non-smokers 1.5-2.4% COHb Smokers 1.8-10.0% COHb Traffic Policemen Non-smokers 1.5-2.3% COHb Smokers 3.0-8.1% COHb
CO	Lawther (291)	IR	Blood (Man)	Elevated levels in heavy smokers as high as 13% COHb. Half-life of CO = 4 hr.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
SCN^-	Foulds (165)	C	Serum (Man)	(a) SCN^- concentrations are higher in smokers than in non-smokers. (b) SCN^- levels of patients with tobacco amblyopia are not significantly different from non-smokers. (c) Author suggests that tobacco amblyopia may be an inability to convert CN^- to SCN^-.
SCN^-	Bhown (48)	SCN^-:C Alk. Phos.: King, E.J. and Wootton, I.D.P. Micro-analysis in Medical Biochemistry, 3rd ed., J. & A. Churchill Ltd., England, 1956,p.83.	Serum (Man)	(a) SCN^- concentrations ↑ from 0.24-2.0 (non-smokers) to 0.41-2.48 mg %. (b) Corresponding ↑ in alkaline phosphatase from 1.0-6.64 (smokers) to 3.41-8.04 K.A. units for non-smokers.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
SCN^-	Beck (37)	NMG	Serum (Woman)	Serum SCN^- levels ↑ from 0.27 mg% (non-smokers) to 0.37 mg%.
			Saliva (Woman)	Salivary SCN^- levels ↑ from 18.4 mg% to 21.4 mg%.
			Cervical mucus (Woman)	No difference - 1.6 mg%.
SCN^-	Yacoub (575)	C	Urine (Man)	Urinary SCN^- ↑ as a function of the no. of cigarettes/day: Non-smokers → 4.5 mg/liter 1-10 cigs/day → 9.3 mg/liter 10-20 cigs/day → 16.3 mg/liter 20-30 cigs/day → 21.0 mg/liter 30+ cigs/day → 27.8 mg/liter
SCN^-	Pettigrew (415)	C	Plasma (Man)	(a) Plasma SCN^- levels ↑ from 36 µmole/L (non-smokers) to 65 µmole/L. (b) Plasma SCN^- levels ↓ to non-smoking level in 4 weeks of no smoking.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings	
SCN^-	Linnell (306)	SPF	Urine (Man)	Smokers have ↑ excretion of SCN^- in urine (207.8 µmoles/24 hrs) compared with 90.5 µmoles/24 hrs for non-smokers.	
SCN^-	Dastur (129)	SPF	Plasma (Man)	SCN^- higher in smokers than non-smokers.	
SCN^-	Bruce (72)	C	Plasma (Man)	1.6 µg/ml of SCN^- in plasma of non-smokers.	
Free CN^-	Maehly (315)	SPF	Blood (Man)	Smokers	Non-smokers
				2.0-13.0 µg/100 ml	3.5-10.1 µg/100 ml
Free SCN^-			Urine (Man)	3.1- 6.5 µg/ml	1.1- 3.8 µg/ml

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
SCN^-	Pettigrew (416)	C	Plasma (Man)	(a) There was a significant ↑ in plasma SCN^- levels from 45.8 (non-smokers) to 86.4 µmole/liter of plasma. (b) Plasma SCN^- levels were also significant for smokers vs. tobacco amblyopes (36.7 µmole/liter).
CN^-	Pettigrew (416)	C	Blood (Man)	There was no significant difference in whole blood CN^- among smokers (0.8±1 SD), non-smokers (1.5±0.9 SD) and tobacco amblyopes (1.4±1.7 SD) nmole/g blood.
CN^-	Ansell (9)	C	Urine (Man)	(a) Non-smokers 6.7 µg% (b) Smokers 17.4 µg%

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
SCN^-	Densen (135)	SPF	Urine Saliva Serum (Man)	(a) Smoking → ↑ SCN^- levels in saliva of smokers vs. non-smokers. (b) Smoking → detectable amounts of SCN^- in serum of smokers vs. non-smokers. (c) SCN^- levels ↑ in urine of smokers.
SCN^-	Langmann (285)	SPF	Saliva (Man)	(a) Smokers in each clinical group (normal, gastric ulcer, gastric cancer) had ↑ SCN^- salivary concentrations than non-smokers. (b) Gastric cancer patients had significantly lower SCN^- salivary concentrations than gastric ulcer patients or normal patients regardless of smoking habits.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
SCN^-	Dogon (143)	Sumner and Somers Chemistry and Methods of Enzymes, Academic Press, New York 1947, p.312	Saliva (Man)	(a) SCN^- concentrations were significantly higher in smokers. (b) Ca^{++} was markedly lower in smokers. (c) K^+ ↑ in smokers compared to non-smokers.
SCN^-	Bourke (61)	C	Blood (Man)	Smoking ↑ mean serum SCN^- from 0.2 mg (non-smokers) to 0.56 mg/100 ml.
SCN^-	Courant (116)	C	Saliva (Man)	(a) Statistically significant ↑ in SCN^- saliva level of smokers. (b) SCN^- level ↑ with no. of cigarettes smoked.
SCN^-	Barylko-Pikielna (33)	SPF	Urine (Man)	(a) Smoking ↑ SCN^- from 16.28 mg (non-smokers) to 23.41 mg/liter.
			Saliva (Man)	(b) Smoking ↑ SCN^- from 3.73 mg% (non-smokers) to 15.48 mg%.
CN^- SCN^-	Wilson (570)	SPF	Plasma (Man)	(a) Plasma SCN^- levels in smokers were much ↑ than non-smokers. (b) Plasma CN^- levels were higher but not statistically significant.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
SCN^-	Dacre (123)	SPF	Saliva (Man)	Smokers 177.4 µg/ml Non-smokers 52.4 µg/ml
SCN^-	Dacre (123)	SPF	Sputum (Man)	Smokers 36.7 µg/ml Non-smokers 19.9 µg/ml
SCN^-	Cruz Urbina (121)	Barker,M.H. & Linberg, H.A. J.Biol.Chem. 117:1591,1941	Saliva (Man)	Smokers 0.23-0.38 mg% Non-smokers 0.0048-0.191 mg%
SCN^-	Wray (571)	Levinson,S.A.& McFate,R.P. Clin. Laboratory Diagnosis, 5th ed.,p.419, citing M.H.Barker, Lea & Febinger,Phila.,1956	Saliva (Man)	Salivary SCN^- levels ↑ from 11.91 mg% (non-smokers) to 16.87 mg%.
SCN^-	Djuric (141)	SPF	Urine (Man)	(a) Smokers - 3-17.5 mg/liter. Non-smokers - trace amount. (b) No. of cigarettes smoked and/or brand → considerable variation in concentration.
SCN^-	Eliakis (148)	C	Serum (Man)	Serum SCN^- levels ↑ as a function of the no. of cigarettes/day: Non-smokers → 25-300 µg/100 ml < 10 cigs/day → 150-700 µg/100 ml 10-20 cigs/day → 350-850 µg/100 ml 20-40 cigs/day → 480-1100 µg/100 ml +40 cigs/day → 680-1800 µg/100 ml

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings	
Polonium-210	Bogner (58)	NMG	Urine (Man)	Smokers excrete 5 times more Po-210 than non-smokers.	
Lead-210	Bogner (58)	NMG	Urine (Man)	Smokers excrete 2 times more Pb-210 than non-smokers.	
Polonium-210	Bogner (58)	Alpha-SPF	(Man)	pCi/100 g tissue	
				Smokers	Non-smokers
			Lung	0.65	0.31
			Liver	1.25	1.03
			Kidney	0.79	0.80
			Muscle	0.08	0.08
			Blood	0.19	0.13
			Bone	3.16	3.05
			Heart	0.24	0.26

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
Thorium-228	Petushkov (418)	SCIN	Expired breath (Man)	(a) Expired air of smokers contained 0.28±0.03 pCi/liter. (b) Ash from one cigarette contained 0.09 pCi.
Polonium-210	Little (307)	Gas Flow Proportioned Counter	Blood (Man)	Concentration in smokers was 1.72 pCi/kg blood compared to 0.76 pCi for non-smokers.
Polonium-210	Little (308)	Gas Flow Proportioned Counter	Blood (Man)	(a) Concentration in smokers was 1.43 pCi/kg blood. (b) Determined $t_{\frac{1}{2}}$ in blood to be approximately 100 days.
Bromine-82	Wehner (553)	Gamma ray spectrometry	Blood (Dog)	(a) Dogs which smoked neutron activated cigarettes had blood levels of 0.125-0.145 µg Br/cigarette 30 min after smoking. (b) Blood levels appeared to be linearly related to the number of cigarettes smoked, although total body counts did not.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
Lead	Lehnert (297)	AAS	Blood (Man)	There was no significant statistical difference (t test) between 16.3±4.6 µg% (smokers) and 16.4±4.8 µg% for non-smokers.
Cadmium	Lewis (303)	AAS	Kidney Liver Lung (Man)	Smokers had significantly ↑ mean composite value of cadmium per organ (15.8 mg) than non-smokers (6.63 mg).
Lead	Jones (248)	AAS	Blood (Man)	No statistical significance between 16-42 µg/100 ml (non-smokers) and 18-49 µg/100 ml for smokers.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
Nitrogen	O'Brien (396)	GC	Urine Blood (Man)	(a) Small but statistically insignificant ↑ in partial pressure of N_2 found in blood and urine of smokers (3 mm Hg higher than for non-smokers). (b) Suggests presence of ↑ ventilation perfusion (VA/Q) inequality in smokers.
Smoke	Nishimura (384)	CC,UV	Urine (Man)	Heavy smokers show a higher incidence of compound IV (believed to be cinnabarinic acid) in urine than non-smokers.
Methanol	Majchrowicz (316)	GC	Urine (Man)	Normal levels: 0.02-0.2 mg/100 ml.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings	
				Percent Retention	
Smoke	Dalhamn (126)		Expired air (Man)	In Mouth	Total (Mouth + Lungs)
Acetaldehyde		GC		60	99
Isoprene		GC		20	99
Acetone		GC		56	86
Acetonitrile		GC		74	91
Toluene		GC		29	93
Carbon monoxide		GC		3	54
Particulates		Fluorometry		16	96
Furfural	Rice (446)	NMG	Urine (Man)	Not stated.	

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
Acetonitrile	McKee (328)	GC,MS	Urine (Man)	Smokers 0.12 µg/ml Non-smokers 0.003 µg/ml Definite relationship between smoking and concentration r = 0.707.
3,4-Benzpyrene	Mallet (317)	FS	Urine (Man)	At necropsy: 50 year old smoker → 1.8 µg/liter 10 year old child → 3.0 µg/liter (Polluted city atmosphere)
Polycyclic hydrocarbons (e.g. benzpyrene)	Vassar (536)	Fluorescence Microscopy	Lung Sputum (Man)	(a) Direct positive relationship between no. of cigarettes and no. of fluorescent macrophages. (b) Fluorescence possibly due to polycyclic hydrocarbons taken up by histiocytes.

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
3,4-Benzpyrene N-methyl aniline	Pelkonen (410)	*In vivo* enzyme assay; SPF	Placenta and fetal liver (Man)	(a) Average benzpyrene (BP) hydroxylase from placentas of smoking mothers significantly ↑ than non-smoking mothers, most of whom had no BP activity at all. (b) No statistically significant differences in N-methyl aniline demethylase in fetal livers or placentas in infants of smoking and non-smoking mothers. (c) No statistically significant difference in fetal liver BP hydroxylase between infants of smoking and non-smoking mothers.
1,2,3,4-dibenzopyrene	Maly (318)	FS	Urine (Man)	Smokers 0.001 µg/ml Non-smokers 0.0003 µg/ml
bis(*p*-chlorophenyl) acetic acid (DDA)	Lee (295)	GLC	Urine (Man)	Smokers 0.034 µg/ml Non-smokers 0.0046 µg/ml

TABLE 1 (cont.)

AGENTS IN CIGARETTE SMOKE FOUND IN BIOLOGICAL FLUIDS FOR ASSESSMENT OF SMOKE INTAKE

Component	Reference	Method of Analysis	Presence in Tissue or Fluid	Concentration/Findings
Acetaldehyde	McKee (328)	GC,MS	Urine (Man)	Smokers 0.199 µg/ml Non-smokers 0.019 µg/ml Poor correlation with smoking r = 0.0019
Propionaldehyde	McKee (328)	GC,MS	Urine (Man)	Smokers 0.0036 µg/ml Non-smokers 0.0027 µg/ml Poor correlation with smoking r = 0.045
Acetone	McKee (328)	GC,MS	Urine (Man)	Smokers 0.819 µg/ml Non-smokers 0.848 µg/ml Poor correlation with smoking r = 0.0001
Methylethyl Ketone	McKee (328)	GC,MS	Urine (Man)	Smokers 0.0127 µg/ml Non-smokers 0.0134 µg/ml Poor correlation with smoking r = 0.0005
Methanol	McKee (328)	GC,MS	Urine (Man)	Smokers 0.528 µg/ml Non-smokers 0.541 µg/ml Poor correlation with smoking r = 0.0029

The published literature is in agreement that thiocyanate levels in either saliva, blood, or urine of smokers are higher than the levels found in non-smokers. Numerous investigators have reported an increase in plasma thiocyanate levels (SCN^-) in smokers, Foulds,[165] Bhown,[48] Pettigrew,[415,416] Dastur,[129] Densen,[135] Bourke,[61] Beck,[37] and Wilson.[570] Eliakis[148] states that serum SCN^- levels increase as a function of the number of cigarettes smoked per day. A similar relationship has been reported for urinary SCN^- levels (Yacoub[575]) while most reports simply show a higher level of urinary SCN^- in smokers, Linnell,[306] Maehly,[315] Densen,[135] Barylko-Pikielna,[33] and Djuric.[141] Likewise, salivary SCN^- levels are higher in smokers, Langmann,[285] Densen,[135] Dogen,[143] Courant,[116] Barylko-Pikielna,[33] Dacre,[123] Cruz Urbina,[121] and Wray,[571] but wide daily variations in the level of SCN^- in saliva have been reported (Dacre[123]).

Determination of SCN^- in body fluids is uncomplicated, rapid and inexpensive, and it would be ideal if these levels were a reliable index of smoke intake. Moreover, Pettigrew[415] reports that plasma SCN^- levels gradually drop to non-smoking levels within four weeks after the cessation of smoking. This would seem to indicate that the higher levels seen in smokers are directly associated with smoking. However, although SCN^- levels are elevated and roughly proportional to the level of smoking, subject variability precludes usage of SCN^- concentrations as a reliable index of individual smoking consumption. Densen[135] also reported wide variations among individuals and concludes that these variations may indicate metabolic adjustments to years of tobacco exposure. Djuric[141] has found considerable individual differences in urinary levels of thiocyanate and these variations may reflect dietary intake since many foods, e.g., almonds, cabbage, garlic, mustard, radishes, etc., give rise to thiocyanate in body tissues and could mask the effects of smoking.

The influence of body cyanide may introduce additional complications in SCN^- determination because blood samples are not suitable for the detection of low cyanide concentrations due to the high rate of metabolism by the enzymatic Rhodanese or β-mercaptopyruvate trans-sulfurase. Thus, this may account for the discrepancy of Maehly[315] who reported a higher cyanide level in the blood of smokers, whereas Pettigrew[416] has observed no difference in whole blood cyanide concentrations.

Therefore, despite the fact that smokers have higher thiocyanate levels in body fluids, the large degree of variability within and between individuals makes measurement of thiocyanate concentrations unsuitable as a reliable measure of smoke intake.

The determination of carbon monoxide (CO) in body tissues and expired air has been pursued by numerous investigators, and despite many variables (e.g., occupation, sex, health status, or environment) which might obscure the results, it can be concluded that chronic smokers have higher carboxyhemoglobin (COHb) levels than non-smokers. Employing spectrophotometric methods of analysis, Bowden,[62] Yacoub,[574] and Jones[248] have reported five

percent and higher COHb levels in smokers. These methods measure blood CO levels indirectly by measuring COHb saturation.

Landaw[283] reduced CO to CH_4 in a H_2 stream at 300°C over a metallic surface. The CH_4 was then detected with gas chromatography using a flame ionization detector. He found a linear correlation between CO levels in expired breath and blood. Landaw further reported great individual variability despite very similar smoking habits.

Anderhub[7] and Stewart[511] used a CO-oximeter to measure COHb. The instrument is rapid and precise but has one major disadvantage in that it must be calibrated daily against a known standard of human blood which must be determined by gas chromatographic or other instrumentation.

Cohen,[107] Ringold,[448] and Stewart[511] measured CO in expired air. The advantages of this method include the ease of sampling, its rapidity, and the non-invasive aspect of sampling. On the other hand, this method necessitates a sampling device which is impermeable to CO and capable of retaining gas samples without change in composition. Broad variations could also result due to collection techniques.

Stewart[511] has reported a good relationship between CO levels and smoking habits up to 1.5 packs per day. Beyond this point he reports no further appreciable increase in CO levels. Based on these findings the CO levels could be used to measure the degree of smoke for intake among light smokers, but would not permit discrimination of smoke intake on a daily basis beyond the 1.5 pack level.

Other agents have been measured in an attempt to quantitate the dose of smoke an individual actually receives. These agents include lead, cadmium, acetonitrile, some polycyclic hydrocarbons, and the radioactive elements polonium-210, lead-210, thorium-228 and bromine-82.

Jones[248] found no significant statistical difference in blood lead levels of smokers when compared with non-smokers. This confirms identical results published by Lehnert[297] using atomic absorption spectroscopy. Lewis[303] reported finding higher mean composite levels of cadmium per organ in the liver, kidney, and lungs at necropsy in humans who smoked. Although smokers do accumulate cadmium with cigarette-pack-years, tissue biopsy is far too drastic a procedure to use for quantitating smoke intake. Additionally, certain foods contain measurable amounts of cadmium (e.g., fish, wheat, oats, and many dairy products) which could influence the results.

Dalham[126] measured the percent retention in humans of acetonitrile present in smoke using gas chromatographic analyses of expired breath. He found a total of 74% retention in the mouth and a 91% retention in mouth and lungs. McKee[328] has reported a definite correlation ($r = .707$) between smoking and the concentration of acetonitrile in the urine. This is a surprisingly high correlation. No mention was made of the cigarette brand, filtered or non-filtered. Smoke intake was based on the smoker's subjective evaluation. This finding should be evaluated more fully.

Some polycyclic hydrocarbons, most notably 3,4-benzpyrene, have been found in human urine, sputum, and in lung biopsy tissue. Vassar,[536] using fluorescence microscopy, reports a direct positive relationship between the number of cigarettes smoked and the number of fluorescent macrophages in the lung; this finding is believed to be a result of polycyclic hydrocarbons being taken up by the histiocytes. A significant increase in the activity of aryl hydrocarbon hydroxylase has been seen in the placentas of smoking mothers (Pelkonen[410]). However, Mallet[317] found 3,4-benzpyrene at necropsy in the urine of a smoker, but found even higher levels in a child raised in the polluted atmosphere of a large city. This entire area concerning the relationship of fluorescent macrophages and enzyme inducibility with exposure to polycyclic hydrocarbons has too many variables to be indicative of smoke intake since benzpyrene is found in car exhausts, in certain foods, etc.

Recently attempts have been made to detect in smokers radioisotopes which occur naturally in tobacco smoke. Petushkov,[418] working with thorium-228, tried to clarify the peculiarity of distribution and the rapidity of removal of thorium-228 and its decomposition products after it is transferred from smoke to humans. The radionuclides, polonium-210 and lead-210, have been found in higher levels in body fluids of smokers vs. non-smokers (Bogner[58]) (Little,[307,308]) and are a direct result of increased absorption of these radioisotopes from cigarette smoke. Wehner[553] has gone one step further and by means of neutron activation, labeled cigarettes with bromine-82 and measured the amount of gamma radiation present in dog's blood after smoking these cigarettes. Although this method is relatively easy in both procedure and analysis, it exposes the test subject to radiation.

C. COMPOSITION OF CIGARETTE SMOKE AND METHODS OF ANALYSIS

Individual chemical components of smoke that have been reported in the literature are tabulated in the following pages. An attempt has been made to group individual compounds according to the chemical classifications used by previous workers. Data on the amount in smoke, if available, are also provided for each compound. All data are expressed in µg/cigarette. It was necessary to assume cigarettes contained one gram of tobacco, the volume of a puff is 35 ml, and 8 puffs can be taken from one cigarette. Frequently different amounts were reported by different workers. For these compounds the range of values is provided.

The major objective of this report was to select a main stream cigarette component that when quantitated in body tissues would serve as a measure of smoke intake. Selection of an appropriate marker compound can be attempted, however, only if its concentration in the appropriate body fluid is known along with some understanding of its detectability. In view of the limited information on tissue distribution of individual chemical compounds in smoke, it was impossible to evaluate a priori a suitable marker compound. To overcome this limitation we have taken the concentration of the compound reported in smoke along with its analytical detectability and calculated the sample size of body fluid needed to measure the marker after smoking one cigarette. This required an assumption that each compound distributed itself uniformly throughout soft tissues (body mass less bone).

The sample size needed to provide sufficient concentration for analysis of the marker in body fluid is calculated by dividing the sensitivity of the method by the quantity found in one gram of tissue (tissue fluid). The method of analysis for each compound and the name of the investigators are listed on the table immediately following one containing the estimated sample sizes.

Abbreviations Used for Compounds Reported in Smoke

t = Trace amount.

Q = Smoke component was identified, but not quantitated.

a = Original published data reported as per puff. To obtain values per cigarette, all values were multiplied by eight.

b = Original published data based on grams of tobacco smoked. The values in this table were calculated on the basis of a one-gram cigarette.

c = Original published data reported as amount per liter of smoke. The values in this table were calculated on the basis of a 280-ml (35 x 8) volume of smoke from one cigarette.

d = Original published data reported as vol. %. Calculations were based on a 280-ml volume of smoke.

e = Original published data reported as mole %. Values in this table were converted to µg/cigarette on the basis of a 280-ml volume of smoke.

f = Original published data reported as ppm. Values in this table were converted to µg/cigarette on the basis of a 280-ml volume of smoke.

TABLE 2-A

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Alcohols				
n-Butyl alcohol	5	10	79	127
sec-Butyl alcohol	4	10	63	159
Isobutyl alcohol	6	10	95	105
Ethanol	2	10	32	313
Furfuryl alcohol	5.7	0.1	90	1.1
Glycerol	4,200	10	6.7×10^4	0.15
Methanol	180	10	2,857	3.5
	100-200	10	1,587-3,175	6.3-3.1
	90	10	1,428	7
Menthol	350-580	10	5,554-9,205	1.8-1.1
	200-500	10	3,175-7,936	3.1-1.3
n-Propyl alcohol	4	10	63	159
	4.8[a]	10	76	132
Isopropyl alcohol	Q	0.1	---	---
Phytol	14	10	222	45.0
Propylene Glycol	400-1,000	10	6,349-15,873	1.6-0.6
	330	10	5,238	1.9
Solanesol	130	1,000	2,063	485

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Alcohols			
n-Butyl alcohol	5	GCFID	Grob (186)
sec-Butyl alcohol	4	GCFID	Grob (186)
Isobutyl alcohol	6	GCFID	Grob (186)
Ethanol	2	GCFID	Grob (186,185,184)
Furfuryl alcohol	5.7	MS,UV,GC	Guvernator (199)
Glycerol	4,200	GC	Laurene (288)
Methanol	180	GCFID	Grob (186,185,184)
	100-200	GCTCD	Newsome (378)
	90	GCTCD	Irby (235)
Menthol	350-580	GLC	Mitchell (340)
	200-500	GCTCD	Lyerly (311)
n-Propyl alcohol	4	GC,IR	Johnstone (246)
	4.8[a]	GCFID	Grob (186)
Isopropyl alcohol	Q	MS	Grob (188)
Phytol	14	GC,IR	Rodgman (452)
Propylene Glycol	400-1,000	GCTCD	Lyerly (311)
	330	GC	Laurene (288)
Solanesol	130	IR	Mold (344)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Aldehydes				
Acetaldehyde	730	10	11,587	0.9
	720-850	10	11,428-13,492	0.9-0.7
	1,000	---	15,873	---
	592[a]	10	9,395	1.1
	280-1,310	1,000	4,444-20,794	225-48
	1,200	20,000	19,048	1,050
Acrolein	74[a]	10	1,168	8.6
	45	10	714	14
	54-83	10	857-1,317	11.7-7.6
Methacrolein	8	10	127	79
n-Butyraldehyde	10	10	158	63
	8	10	127	79
Isobutyraldehyde	12	10	190	53
	30	10	476	21
	32	10	508	20
2-Methylbutyraldehyde	Q	0.1	---	---
Caproaldehyde	12	10	190	53
Crotonaldehyde (2-Butenal)	14-16	10	222-254	45-39
	16	10	254	39

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Aldehydes			
Acetaldehyde	730	GCTCD	Irby (235)
	720-850	GC	Laurene (290)
	1,000	NMG	Wynder (572)
	592[a]	GCFID	Terrell (520)
	280-1,310	PC,UV	Buyske (77)
	1,200	UV,IR	Mold (345)
Acrolein	74[a]	GCFID	Terrell (520)
	45	GCFID	Grob (186,185,184)
	54-83	GC	Laurene (290)
Methacrolein	8	GCFID	Grob (186,185,184)
n-Butyraldehyde	10	GCFID	Grob (186,185,184)
	8	GCTCD	Newsome (378)
Isobutyraldehyde	12	GCFID	Grob (186,185,184)
	30	GCTCD	Irby (235)
	32	GCTCD	Newsome (378)
2-Methylbutyraldehyde	Q	MS	Grob (188)
Caproaldehyde	12	GCFID	Grob (186)
Crotonaldehyde (2-Butenal)	14-16	GCFID	Grob (186,185,184)
	16	GCTCD	Newsome (378)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Formaldehyde	20	20,000	317	63,091
	32	10	508	20
	29-66	3,500	460-1,047	7,609-3,343
	40-84	1,000	635-1,333	1,575-750
Furfural (2-furaldehyde)	100	20,000	1,587	12,602
	45-110	1,000	714-1,746	1,401-573
Glyoxal (oxalaldehyde)	Q	10	---	---
Methyl Glyoxal	Q	---	---	---
2-Methylpent-4-enal	Q	0.1	---	---
2,4-Pentadienal	Q	0.1	---	---
Pivaldehyde	4	10	---	---
Propionaldehyde	40	10	635	16
	15	20,000	238	84,034
	50	10	794	13
Mixture: Propionaldehyde + Isobutyraldehyde	13[b]	10	206	49
n-Valeraldehyde	1	10	16	625
	8	10	127	79
Isovaleraldehyde	20	10	317	32
	24	10	381	26
2-Methylvaleraldehyde	8	10	127	79

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Formaldehyde	20	UV,IR	Mold (345)
	32	GCTCD	Newsome (378)
	29-66	SPF	Spincer (504)
	40-84	SPF	Stauffer (506)
Furfural (2-furaldehyde)	100	UV,IR	Mold (345)
	45-110	PC,SPF	Buyske (77)
Glyoxal (oxalaldehyde)	Q	GCFID	Grob (186)
Methyl Glyoxal	Q	NMG	Wahl (542)
2-Methylpent-4-enal	Q	MS	Grob (188)
2,4-Pentadienal	Q	MS	Grob (188)
Pivaldehyde	4	GCFID	Grob (186,185,184)
Propionaldehyde	40	GCFID	Grob (186,185,184)
	15	UV,IR	Mold (345)
	50	GCTCD	Irby (235)
Mixture: Propionaldehyde + Isobutyraldehyde	13[b]	GC	Mokhnachev (342)
n-Valeraldehyde	1	GCTCD	Newsome (378)
	8	GCFID	Grob (186)
Isovaleraldehyde	20	GCFID	Grob (186,185,184)
	24	GCTCD	Newsome (378)
2-Methylvaleraldehyde	8	GCTCD	Newsome (378)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Ketones				
Acetone	360	10	5,714	1.8
	390	10	6,190	1.6
	650	20,000	10,317	1,939
	370-560	0.1	5,873-8,889	0.017-0.011
Acetophenone	Q	0.1	---	---
p-Methoxyacetophenone	1	10	16	625
m-Methoxyacetophenone	2	10	32	313
2-Butanone	80	10	1,270	7.9
	80	10	1,270	7.9
	250	20,000	3,968	5,040
3-Methyl-2-butanone	6	10	95	105
	8	10	127	79
2,3-Butanedione	12	10	190	53
Butenone	28	10	444	23
	32	10	516	19

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Ketones			
Acetone	360	GCFID	Grob (186,185,184)
	390	GCTCD	Irby (235)
	650	UV,IR	Mold (345)
	370-560	GC,MS	Laurene (290)
Acetophenone	Q	GC,MS	Kaburaki (250)
p-Methoxyacetophenone	1	GLC	Carruthers (86)
m-Methoxyacetophenone	2	GLC	Carruthers (86)
2-Butanone	80	GCFID	Grob (186,185,184)
	80	GC,IR	Spears (503)
	250	UV,IR	Mold (345)
3-Methyl-2-butanone	6	GCFID	Grob (186,185,184)
	8	GCTCD	Newsome (378)
2,3-Butanedione	12	GCTCD	Newsome (378)
Butenone	28	GCFID	Grob (186,185,184)
	32	GCFID	Newsome (378)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Methyl Butenone	51[a]	10	813	12
2-Methyl-buten-1-one-3	Q	0.1	---	---
Coumarin	Q	0.1	---	---
6-Methyl-coumarin	Q	0.1	---	---
4-Heptanone	Q	10	---	---
2-Hexanone	Q	0.1	---	---
3-Hexanone	Q	0.1	---	---
Cyclohexanone	Q	0.1	---	---
1-Indanone	Q	0.1	---	---
3-Methyl-1-indanone	Q	0.1	---	---
4-Methyl-1-indanone	Q	0.1	---	---
5-Methyl-1-indanone	Q	0.1	---	---
6-Methyl-1-indanone	Q	0.1	---	---
Maltol (2-hydroxy-3-methyl-4-pyrone)	5-10	0.1	79-159	1.3-0.6
2-Pentanone	12	10	190	53
	16	10	254	39

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Methyl butenone	51[a]	GCFID	Grob (186)
2-Methyl-buten-1-one-3	Q	MS,GC	Grob (188,187)
Coumarin	Q	GC,MS	Kaburaki (250)
6-Methyl-coumarin	Q	GC,MS	Kaburaki (250)
4-Heptanone	Q	GC	Dymond (146)
2-Hexanone	Q	MS,GC	Grob (188,187)
3-Hexanone	Q	MS,GC	Grob (188,187)
Cyclohexanone	Q	MS,GC	Grob (188,187)
1-Indanone	Q	MS,GC	Kaburaki (250)
3-Methyl-1-indanone	Q	MS,GC	Kaburaki (250)
4-Methyl-1-indanone	Q	MS,GC	Kaburaki (250)
5-Methyl-1-indanone	Q	MS,GC	Kaburaki (250)
6-Methyl-1-indanone	Q	MS,GC	Kaburaki (250)
Maltol (2-hydroxy-3-methyl-4-pyrone	5-10	TLC,UV,GC,MS	Elmenhorst (150)
2-Pentanone	12	GCFID	Grob (186,185,184)
	16	GCTCD	Newsome (378)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
3-Methyl-2-pentanone	Q	0.1	---	---
4-Methyl-2-pentanone	Q	0.1	---	---
3-Methylcyclopentanone	Q	0.1	---	---
3-Pentanone	4	10	63	159
	12	10	190	53
2-Methyl-3-pentanone	Q	0.1	---	---
2,4-Dimethyl-3-pentanone	Q	0.1	---	---
Cyclopentanone	Q	0.1	---	---
1-Penten-3-one	45	10	714	14
1-Penten-4-one	Q	0.1	---	---
2,3-Pentanedione	Q	0.1	---	---
Phthalide	Q	0.1	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
3-Methyl-2-pentanone	Q	MS	Grob (188)
4-Methyl-2-pentanone	Q	MS,GC	Grob (188,187)
3-Methylcyclopentanone	Q	MS	Grob (188)
3-Pentanone	4	GCTCD	Newsome (378)
	12	GCFID	Grob (186,185,184)
2-Methyl-3-pentanone	Q	GC,MS	Grob (188,187)
2,4-Dimethyl-3-pentanone	Q	GC,MS	Grob (188)
Cyclopentanone	Q	GC,MS	Grob (188,187)
1-Penten-3-one	45	GCFID	Grob (186)
1-Penten-4-one	Q	GC,MS	Grob (188)
2,3-Pentanedione	Q	GC,MS	Grob (188,187)
Phthalide	Q	GC,MS	Kaburaki (250)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Esters				
Butyl acetate	1	10	16	625
Ethyl acetate	2	10	32	313
Triacetin (glyceryl acetate)	200-300	10	3175-4762	3.2-2.1
Methyl acetate	8	10	127	79
	10	10	158	63
Solanesol acetate	18	1000	286	3,497
	18	1000	286	3,497
Vinyl acetate	4	10	63	159
	4[a]	10	63	159
Unknown Acetate ester	12.9[b]	0.1	205	0.48
Acrylate	3	10	48	208
Ethyl Butyrate	Q	---	---	---
Ethyl Capronate	1	10	16	625
Ethyl formate	4	10	63	159
Isopropyl formate	5	10	79	127
	4.8[a]	10	76	132
Methyl formate	30	10	476	21
Formate ester	36.3[b]	0.1	576	0.17
Propionate ester	t	0.1	---	---
Ethyl Propionate	Q	---	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Esters			
Butyl acetate	1	GCFID	Grob (186)
Ethyl acetate	2	GCFID	Grob (186,185,184)
Triacetin (glyceryl acetate)	200-300	GCTCD	Lyerly (311)
Methyl acetate	8	GCFID	Grob (186,185,184)
	10	GCTCD	Irby (235)
Solanesol acetate	18	IR	Mold (344)
	18	MP,CC,IR	Rodgman (450)
Vinyl acetate	4	GCFID	Grob (186)
	4[a]	GLC	Newsome (380)
Unknown Acetate ester	12.9[b]	PC,MS	Mokhnachev (342)
Acrylate	3	GCFID	Grob (186,185,184)
Ethyl Butyrate	Q	NMG	Johnstone (243)
Ethyl Capronate	1	GCFID	Grob (186)
Ethyl formate	4	GCFID	Grob (186)
Isopropyl formate	5	GCFID	Grob (186)
	4.8[a]	GLC	Newsome (380)
Methyl formate	30	GCFID	Grob (186,185,184)
Formate ester	36.3[b]	PC,MS	Mokhnachev (342)
Propionate ester	t	PC,MS	Mokhnachev (342)
Ethyl Propionate	Q	NMG	Johnstone (243)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Ethers				
Anisole, (Methoxybenzol)	5	10	79	127
	8	10	127	79
Furan	18	10	286	35
	30	10	476	21
	18	10	286	35
2-Acetylfuran	Q	0.1	---	---
Benzo-(b)-furan	Q	0.1	---	---
Dibenzofuran	0.106	0.1	1.68	59.5
1-Methyldibenzofuran	0.040	0.1	0.64	156
2- and 3-Methyldibenzofuran	0.1	0.1	1.59	63
4-Methyldibenzofuran	0.052	0.1	0.83	120
Methylfuran	20	10	317	32
	20	10	317	32
2-Methylfuran	20	10	317	32
	20	10	317	32

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Ethers			
Anisole, (Methoxybenzol)	5	GCFID	Grob (186)
	8	GLC	Carruthers (86)
Furan	18	GCFID	Grob (186,185,183)
	30	GCTCD	Irby (235)
	18	GC,IR	Spears (503)
2-Acetylfuran	Q	MS	Grob (188)
Benzo-(b)-furan	Q	GCFID,MS	Neurath (372)
Dibenzofuran	0.106	GCFID,MS	Hoffmann (216)
1-Methyldibenzofuran	0.040	GCFID,MS	Hoffmann (216)
2- and 3-Methyldibenzofuran	0.100	GCFID,MS	Hoffmann (216)
4-Methyldibenzofuran	0.052	GCFID,MS	Hoffmann (216)
Methylfuran	20	GCFID	Grob (185,184)
	20	GCTCD	Irby (235)
2-Methylfuran	20	GCFID	Grob (186)
	20	GCTCD	Irby (235)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT

(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
2,5-Dimethylfuran	16	10	254	39
	3.5-48	10	56-762	18-13
Tetrahydrofuran	8	10	127	79
5-Methyl furfurole	Q	10	---	---
5-Hydroxymethylfurfurole	Q	10	---	---
Guaiacol, (o-Methoxyphenol)	13	0.1	206	0.48
	15-25	0.1	238-397	0.42-0.25
Methylcresylether	20	10	317	32
Tetrahydropyran	2	10	32	313
Veratrole (Pyrocatechol, dimethylether)	40	10	635	16

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
2,5-Dimethylfuran	16	GCFID	Grob (186,184)
	3.5-48	GC,IR	Johnstone (246)
Tetrahydrofuran	8	GCFID	Grob (186,185,184)
5-Methyl furfurole	Q	GCFID,IR	Burdick (74)
5-Hydroxymethylfurfurole	Q	GLC	Black (54)
Guaiacol, (o-Methoxyphenol)	13	MS	Spears (503)
	15-25	MS	Rayburn (442)
Methylcresylether	20	GLC	Carruthers (86)
Tetrahydropyran	2	GCFID	Grob (186,185,184)
Veratrole (Pyrocatechol, dimethylether)	40	GLC	Carruthers (86)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Aliphatic Hydrocarbons				
Acetylene	22	10	349	29
	26	10	413	24
n-Butane	56	10	889	11
	70	10	1,111	9
2-Methylbutane	15	10	238	42
	20	10	318	31
1-Nitro-n-butane	0.71	10	11.3	885
1,2-Butadiene	3	10	48	208
1,3-Butadiene	34	10	540	19
2-Methyl-1,3-butadiene	630	0.1	10,000	.01
	500	0.1	7,936	.013
	376	10	5,968	1.7
1-Butene	50	10	794	13
2-Methyl-1-butene	24	10	381	26
	19	10	302	33
3-Methyl-1-butene	1	10	16	625
	15	10	238	42
2,3-Dimethyl-1-butene	0.64	0.1	10	10

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Aliphatic Hydrocarbons			
Acetylene	22	GCTCD	Newsome (378)
	26	GC,IR	Spears (503)
n-Butane	56	GCTCD	Newsome (378)
	70	GC,IR	Spears (503)
2-Methylbutane	15	GCTCD	Newsome (378)
	20	GC,IR	Spears (503)
1-Nitro-n-butane	0.71	GCFID	Hoffmann (217)
1,2-Butadiene	3	GCTCD	Newsome (378)
1,3-Butadiene	34	GCTCD	Newsome (378)
2-Methyl-1,3-butadiene	630	GC,IR,MS	Irby (235)
	500	GC,IR,MS	Spears (503)
	376	GCTCD	Newsome (378)
1-Butene	50	GCTCD	Newsome (378)
2-Methyl-1-butene	24	GC,IR	Spears (503)
	19	GCTCD	Newsome (378)
3-Methyl-1-butene	1	GC,IR	Spears (503)
	15	GCTCD	Newsome (378)
2,3-Dimethyl-1-butene	0.64	GC,IR,MS	Philippe (423)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
3,3-Dimethyl-1-butene	Q	10	---	---
2-Methyl-2-butene	68	10	1,079	9
	54	10	857	12
cis-2-Butene	29	10	460	22
	23	10	365	27
trans-2-Butene	41	10	651	15
	33	10	524	19
3-Butene-1-yne	4[a]	10	64	156
1-Butyne	t	10	---	---
DCS (4,4-Dichlostilbene)	1.5	---	24	---
DDT	0.8	---	13	---
TDE or DDD	1.8	---	29	---
TDEE (Breakdown product of TDE)	0.8	---	13	---
1-Decene	Q	0.1	---	---
Ethane	500	10	7,936	1.3
	410	10	6,508	1.5
	302[a]	10	4,799	2.1

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
3,3-Dimethyl-1-butene	Q	GCTCD	Philippe (425)
2-Methyl-2-butene	68	GC,IR	Spears (503)
	54	GCTCD	Newsome (378)
cis-2-Butene	29	GC,IR	Spears (503)
	23	GCTCD	Newsome (378)
trans-2-Butene	41	GC,IR	Spears (503)
	33	GCTCD	Newsome (378)
3-Butene-1-yne	4[a]	GCTCD	Philippe (425)
1-Butyne	t	GCTCD	Philippe (425)
DCS (4,4-Dichlostilbene)	1.5	NMG	Guthrie (198)
DDT	0.8	NMG	Guthrie (198)
TDE or DDD	1.8	NMG	Guthrie (198)
TDEE (Breakdown produce of TDE)	0.8	NMG	Guthrie (198)
1-Decene	Q	MS	Grob (188)
Ethane	500	GC,IR	Spears (503)
	410	GCTCD	Newsome (378)
	302[a]	GC	Terrell (519)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Nitroethane	1.1	10	17	588
	0.24	10	4	2,500
Ethylene	240	10	3,810	2.6
	176	10	2,794	3.6
1-chloro-2-(p-chlorophenyl)-2-Phenylethylene	Q	0.1	---	---
Heptane	Q	0.1	---	---
n-Hexane	10	10	158	63
	8	10	127	79
1-chloro-5-methyl-Hexane	Q	0.1	---	---
1,3,5-Hexatriene	Q	0.1	---	---
Cyclohexane	3	10	48	208
	3	10	48	208
	3	10	48	208
2,4-DiMe-4-Vinyl-Cyclohexane	5	10	79	127
1-Hexene	3.2[a]	0.1	51	1.96
trans-2-Hexene	0.8[a]	0.1	13	7.7
Cyclohexene	0.08[a]	0.1	1.3	77
1-Methyl-4-isopropylcyclohex-1-ene	Q	0.1	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Nitroethane	1.1	GCFID	Hoffmann (217)
	0.24	GCFID	Rathkamp (441)
Ethylene	240	GC,IR	Spears (503)
	176	GCTCD	Newsome (378)
1-chloro-2-(p-chlorophenyl)-2-Phenylethylene	Q	GC,IR,MS	Miller (336)
Heptane	Q	MS	Grob (188)
n-Hexane	10	GC,IR	Spears (503)
	8	GCTCD	Newsome (378)
1-chloro-5-methyl-Hexane	Q	GC,MS	Bartle (31)
1,3,5-Hexatriene	Q	GC,MS	Bartle (31)
Cyclohexane	3	GCFID	Grob (186,185,184)
	3	GC,IR	Spears (503)
	3	GCTCD	Newsome (378)
2,4-DiMe-4-Vinyl-Cyclohexane	5	GC	Cook (115)
1-Hexene	3.2[a]	GC,IR,MS	Philippe (423)
trans-2-Hexene	0.8[a]	GC,IR,MS	Philippe (423)
Cyclohexene	0.08[a]	GC,IR,MS	Philippe (423)
1-Methyl-4-Isopropylcyclohex-1-ene	Q	MS	Grob (188)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Limonene (Dipentene)	24	10	381	26
	126-200	10	2,000-3,175	5-3.1
	200	10	3,175	3
nC_{12} alkane	1-10	10	16-158	625-63
nC_{13} alkane	1-40	10	16-635	625-16
nC_{14} alkane	1-20	10	16-317	625-32
nC_{15} alkane	1-25	10	16-397	625-25
nC_{16} alkane	2-20	10	32-317	313-32
nC_{17} alkane	4-20	10	63-317	159-32
nC_{18} alkane	1-20	10	16-317	625-32
nC_{19} alkane	1-10	10	16-158	625-63
nC_{20} alkane	5-20	10	79-317	127-32
nC_{21} alkane	6-20	10	95-317	105-32
nC_{22} alkane	4-20	10	63-317	159-32
nC_{23} alkane	4-10	10	63-158	159-63
nC_{24} alkane	3-20	10	48-317	208-32
nC_{25} alkane	3-30	10	48-480	208-21
nC_{26} alkane	3-30	10	48-480	208-21

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (ug)	Method of Analysis	Reference
Limonene (Dipentene)	24	GCFID	Grob (186)
	126-200	GC,IR	Johnstone (246)
	200	GC	Cook (115)
nC_{12} alkane	1-10	CC,GCFID	Spears (502)
nC_{13} alkane	1-40	CC,GCFID	Spears (502)
nC_{14} alkane	1-20	CC,GCFID	Spears (502)
nC_{15} alkane	1-25	CC,GCFID	Spears (502)
nC_{16} alkane	2-20	CC,GCFID	Spears (502)
nC_{17} alkane	4-20	CC,GCFID	Spears (502)
nC_{18} alkane	1-20	CC,GCFID	Spears (502)
nC_{19} alkane	1-10	CC,GCFID	Spears (502)
nC_{20} alkane	5-20	CC,GCFID	Spears (502)
nC_{21} alkane	6-20	CC,GCFID	Spears (502)
nC_{22} alkane	4-20	CC,GCFID	Spears (502)
nC_{23} alkane	4-10	CC,GCFID	Spears (502)
nC_{24} alkane	3-20	CC,GCFID	Spears (502)
nC_{25} alkane	3-30	CC,GCFID	Spears (502)
nC_{26} alkane	3-30	CC,GCFID	Spears (502)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
nC_{27} alkane	3-10	10	48-158	208-63
nC_{28} alkane	1-20	10	16-317	625-32
nC_{29} alkane	6-10	10	95-158	105-63
nC_{30} alkane	12-100	10	190-1,587	53-6.3
nC_{31} alkane	20-350	10	317-5,556	32-1.8
nC_{32} alkane	20-200	10	317-3,175	32-3.2
nC_{33} alkane	6-250	10	95-3,968	105-2.5
Methane	770	10	12,222	0.8
	1,000	10	15,873	0.6
	860[a]	10	13,648	0.7
	1,300	0.1	20,635	0.005
Nitromethane	0.53	10	8.4	1,191
	0.18	10	2.9	3,448
Nonane	Q	0.1	---	---
Norphytene	1	---	16	---
Octane	Q	0.1	---	---
2-Methyl-1-octene	Q	0.1	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
nC_{27} alkane	3-10	CC,GCFID	Spears (502)
nC_{28} alkane	1-20	CC,GCFID	Spears (502)
nC_{29} alkane	6-10	CC,GCFID	Spears (502)
nC_{30} alkane	12-100	CC,GCFID	Spears (502)
nC_{31} alkane	20-350	CC,GCFID	Spears (502)
nC_{32} alkane	20-200	CC,GCFID	Spears (502)
nC_{33} alkane	6-250	CC,GCFID	Spears (502)
Methane	770	GCTCD	Newsome (378)
	1000	GC,IR	Spears (503)
	860[a]	GC	Terrell (519)
	1300	MS	Keith (258)
Nitromethane	0.53	GCFID	Hoffmann (217)
	0.18	GCFID	Rathkamp (441)
Nonane	Q	MS	Grob (188)
Norphytene	1	NMG	Wynder (573)
Octane	Q	MS	Grob (188)
2-Methyl-1-octene	Q	GC,MS	Bartle (31)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
n-Pentane	23	10	365	27
	18	10	286	35
2-Methylpentane	6	10	95	105
	5	10	79	127
3-Methylpentane	1	10	16	625
	2	10	32	313
2,4-Dimethylpentane	Q	0.1	---	---
1-Nitro-n-pentane	0.22	10	3.5	2,857
Cyclopentane	1	0.1	16	6
	2	10	32	313
Methylcyclopentane	2	10	32	313
Pentadiene	20	10	317	32
cis-1,3-Pentadiene	15	10	238	42
trans-1,3-Pentadiene	10	10	158	63
1,4-Pentadiene	2	10	32	313
	2	10	32	313
Cyclopentadiene	t	10	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
n-Pentane	23	GC,IR	Spears (503)
	18	GCTCD	Newsome (378)
2-Methylpentane	6	GC,IR	Spears (503)
	5	GCTCD	Newsome (378)
3-Methylpentane	1	GC,IR	Spears (503)
	2	GCTCD	Newsome (378)
2,4-Dimethylpentane	Q	MS	Grob (188)
1-Nitro-n-pentane	0.22	GCFID	Hoffmann (217)
Cyclopentane	1	GC,MS	Spears (503)
	2	GCTCD	Newsome (378)
Methylcyclopentane	2	GCTCD	Newsome (378)
Pentadiene	20	GCFID	Grob (186,185,184)
cis-1,3-Pentadiene	15	GCTCD	Newsome (378)
trans-1,3-Pentadiene	10	GCTCD	Newsome (378)
1,4-Pentadiene	2	GC,IR	Spears (503)
	2	GCTCD	Newsome (378)
Cyclopentadiene	t	GCTCD	Philippe (425)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
1-Pentene	19	10	302	33
	15	10	238	42
2-Methyl-1-pentene	0.4[a]	0.1	6	17
3-Methyl-1-pentene	0.2[a]	0.1	3	33
4-Methyl-1-pentene	3	10	48	208
cis-2-Pentene	8	10	127	79
trans-2-Pentene	15	10	238	42
	12	10	190	53
2-Methyl-2-pentene	2.4[a]	0.1	38	2.6
4-Methyl-2-pentene	3	10	48	208
	3.2[a]	0.1	51	1.9
Cyclopentene	6	10	95	105
1-Methyl-1-Cyclopentene	0.24[a]	0.1	4	25
3-Methyl-1-Cyclopentene	0.08[a]	0.1	1	100
Beta-Pinene	3	10	48	208
Propane	250	10	3,968	2.5
	180	10	2,857	3.5

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
1-Pentene	19	GC,IR	Spears (503)
	15	GCTCD	Newsome (378)
2-Methyl-1-pentene	0.4[a]	GC,IR,MS	Philippe (423)
3-Methyl-1-pentene	0.2[a]	GC,IR,MS	Philippe (423)
4-Methyl-1-pentene	3	GCTCD	Newsome (378)
cis-2-Pentene	8	GCTCD	Newsome (378)
trans-2-Pentene	15	GC,IR	Spears (503)
	12	GCTCD	Newsome (378)
2-Methyl-2-pentene	2.4[a]	GC,IR,MS	Philippe (423)
4-Methyl-2-pentene	3	GCTCD	Newsome (378)
	3.2[a]	GC,IR,MS	Philippe (423)
Cyclopentene	6	GCTCD	Newsome (378)
1-Methyl-1-Cyclopentene	0.24[a]	GC,IR,MS	Philippe (423)
3-Methyl-1-Cyclopentene	0.08[a]	GC,IR,MS	Philippe (423)
Beta-Pinene	3	GCFID	Grob (186)
Propane	250	GC,IR	Spears (503)
	180	GCTCD	Newsome (378)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
1-Nitropropane	0.73	10	12	833
2-Nitropropane	1.1	10	16	625
2-Methylpropane	23	10	365	27
	16	10	254	39
1,1-Dimethylcyclopropane	Q	0.1	---	---
1,2-cis-Dimethylcyclopropane	Q	0.1	---	---
1,2-trans-Dimethylcyclopropane	Q	0.1	---	---
Propadiene	5	10	79	127
	4	10	63	159
Propene	240	10	3,810	2.6
	200	10	3,175	3.2
2-Methylpropene	64	10	1,016	9.8
	55	10	873	12
Propyne	6	10	95	105

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)
AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
1-Nitropropane	0.73	GCFID	Hoffmann (217)
2-Nitropropane	1.1	GCFID	Hoffmann (217)
3-Methylpropane	23	GC,IR	Spears (503)
	16	GCTCD	Newsome (378)
1,1-Dimethylcyclopropane	Q	GC,MS	Bartle (31)
1,2-cis-Dimethylcyclopropane	Q	GC,MS	Bartle (31)
1,2-trans-Dimethylcyclopropane	Q	GC,MS	Bartle (31)
Propadiene	5	GC,IR	Spears (503)
	4	GCTCD	Newsome (378)
Propene	240	GC,IR	Spears (503)
	200	GCTCD	Newsome (378)
2-Methylpropene	64	GC,IR	Spears (503)
	55	GCTCD	Newsome (378)
Propyne	6	GCTCD	Newsome (378)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT (BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Aromatic Hydrocarbons				
9, 9-Dimethylacridan	Q	0.1	---	---
Isopropyl-9,-9-dimethylacridan	Q	0.1	---	---
Acenaphthylene	Q	10	---	---
Anthracene	0.14	10	2.2	4,546
	0.23	10	3.7	2,703
	0.102	1,000	1.6	625,000
Benz(a)anthracene	0.04	10	0.6	16,667
	0.08	10	1.2	8,333
	0.007	10	0.1	100,000
Methylbenz(a)anthracene	Q	0.1	---	---
Dibenz(ah)anthracene	Q	10	---	---
9-Methylanthracene	Q	10	---	---
Methylanthracene	Q	0.1	---	---
Benzene	32	10	508	20
	12-48	10	190-762	53-13
	30	10	476	21

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Aromatic Hydrocarbons			
9, 9-Dimethylacridan	Q	GC,IR,MS	Miller (336)
Isopropyl-9,-9-dimethylacridan	Q	GC,IR,MS	Miller (336)
Acenaphthylene	Q	GLC	Zane (578)
Anthracene	0.14	GLC	Zane (578)
	0.23	GC	Chakraborty (91)
	0.102	CC,UV	Commins (113)
Benz(a)anthracene	0.04	GC	Chakraborty (91)
	0.08	GLC	Ayres (21)
	0.007	GCFID	Rathkamp (441)
Methylbenz(a)anthracene	Q	GC,IR,MS	Miller (336)
Dibenz(ah)anthracene	Q	GCECD	Robb (449)
9-Methylanthracene	Q	GCECD	Robb (449)
Methylanthracene	Q	GC,IR,MS	Miller (336)
Benzene	32	GCFID	Grob (186,185,184)
	12-48	GC,IR	Johnstone (246)
	30	GC,IR	Spears (503)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Ethylbenzene	7	10	111	90
	7	10	111	90
	<14	10	<222	<45
	10	10	158	63
Isopropylbenzene	11	10	175	57
	11	1,000	175	5,714
1-Ethyl-2-methylbenzene	1.0	10	16	625
1,2,3-Trimethylbenzene	3	10	48	208
1,2,4-Trimethylbenzene	6	10	95	105
	10	10	158	63
1,3,5-Trimethylbenzene	1	10	16	625
	4	10	63	159
	9	10	143	70
	9	10	143	70
Nitrobenzene	0.027	10	0.4	25,000
Phenyl benzene (Biphenyl)	Q	10	---	---
Fluoranthene	0.17	10	2.7	3,704
	0.1	10	1.6	6,250
	0.01	1,000	0.2	5×10^6

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Ethylbenzene	7	GC,IR	Johnstone (246)
	7	GC,IR	Spears (503)
	<14	GCFID	Grob (186)
	10	GC	Cook (115)
Isopropylbenzene	11	GC,IR	Johnstone (246)
	11	FP,UV	Spears (503)
1-Ethyl-2-methylbenzene	1.0	GCFID	Grob (186)
1,2,3-Trimethylbenzene	3	GCFID	Grob (186)
1,2,4-Trimethylbenzene	6	GCFID	Grob (186)
	10	GC	Cook (115)
1,3,5-Trimethylbenzene	1	GCFID	Grob (186)
	4	GCTCD	Newsome (378)
	9	GC,IR	Spears (503)
	9	GC,IR	Johnstone (246)
Nitrobenzene	0.027	GCFID	Rathkamp (441)
Phenyl benzene (Biphenyl)	Q	GCECD	Robb (449)
Fluoranthene	0.17	GC	Chakraborty (91)
	0.1	GC	Cook (115)
	0.01	PC,UV	Van Duuren (532)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Alkylfluoranthene	0.33	10	5.2	1,923
Benzofluoranthene	0.04	10	0.6	16,667
Benzo(b)fluoranthene	0.04	10	0.6	16,667
	Q	10	---	---
Benzo(j)fluoranthene	0.04	10	0.6	16,667
8-Methylfluoranthene	Q	1,000	---	---
Fluorene	0.83	10	13	769
Methylfluorenes	1.4	10	22	455
Benzofluorene	0.09-0.18	10	1.4-2.9	7,143-3,448
Alkylbenzofluorene	0.14-0.17	10	2.2-2.7	4,546-3,704
11-H-Benzo(a)fluorene	0.04	10	0.7	14,286
Methyl-11-H-benzo(a)fluorene	0.04	10	0.7	14,286
Indene	4	10	63	159
Naphthalene	1.85	10	29	345
1-Me-Naphthalene	0.5	10	8	1,250
2-Me-Naphthalene	0.5	10	8	1,250
α, α, α', α'-Dinaphthylene (Perylene)	Q	10	---	---
Benzo(ghi)perylene	Q	10	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Alkylfluoranthene	0.33	GC	Chakraborty (91)
Benzofluoranthene	0.04	GC	Chakraborty (91)
Benzo(b)fluoranthene	0.04	GLC	Ayres (21)
	Q	GCECD	Robb (449)
Benzo(j)fluoranthene	0.04	GLC	Ayres (21)
8-Methylfluoranthene	Q	PC,UV	Van Duuren (532)
Fluorene	0.83	GC	Chakraborty (91)
Methylfluorenes	1.4	GC	Chakraborty (91)
Benzofluorene	0.09-0.18	GC	Chakraborty (91)
Alkylbenzofluorene	0.14-0.17	GC	Chakraborty (91)
11-H-Benzo(a)fluorene	0.04	GLC	Ayres (21)
Methyl-11-H-benzo(a)fluorene	0.04	GLC	Ayres (21)
Indene	4	GC	Cook (115)
Naphthalene	1.85	GCFID	Rathkamp (441)
1-Me-Naphthalene	0.5	GC	Cook (115)
2-Me-Naphthalene	0.5	GC	Cook (115)
α, α, α', α'-Dinaphthylene (Perylene)	Q	GCECD	Robb (449)
Benzo(ghi)perylene	Q	GCECD	Robb (449)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
1,6-DiMe-Naphthalene	1.0	10	16	625
2,6-DiMe-Naphthalene	0.3	10	4.8	2,083
2,7-DiMe-Naphthalene	0.3	10	4.8	2,083
1,3,6-TriMe-Naphthalene	0.7	10	11	909
Nephthacene	Q	0.1	---	---
Phenanthrene	0.72	10	11	909
	0.45	10	7	1,429
	0.2	10	3	3,333
	0.4	10	6	1,667
Alkylphenanthrene	0.48-0.65	10	8-10	1,250-1,000
Dimethylphenanthrene	0.63	10	10	1,000
Chrysene (Benzophenanthrene)	0.06	10	0.95	10,526
	0.096	10	1.5	6,667
Methylchrysene	0.103	10	1.6	6,250
Dimethylchrysene	0.026	10	0.4	25,000
Pyrene	0.12	10	1.9	5,263
	0.113	10	1.8	5,556
	0.09	1,000	14	71,428
	0.05	1,000	0.8	1,250,000

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
1,6-DiMe-Naphthalene	1.0	GC	Cook (115)
2,6-DiMe-Naphthalene	0.3	GC	Cook (115)
2,7-DiMe-Naphthalene	0.3	GC	Cook (115)
1,3,6-TriMe-Naphthalene	0.7	GC	Cook (115)
Nephthacene	Q	GC,IR,MS	Miller (336)
Phenanthrene	0.72	GC	Chakraborty (91)
	0.45	GCFID	Rathkamp (441)
	0.2	GC	Cook (115)
	0.4	GLC	Zane (579)
Alkylphenanthrene	0.48-0.65	GC	Chakraborty (91)
Dimethylphenanthrene	0.63	GC	Chakraborty (91)
Chrysene (Benzophenanthrene)	0.06	GC	Chakraborty (91)
	0.096	GLC	Ayres (21)
Methylchrysene	0.103	GLC	Ayres (21)
Dimethylchrysene	0.026	GLC	Ayres (21)
Pyrene	0.12	GC	Chakraborty (91)
	0.113	GLC	Zane (578)
	0.09	CC,UV	Commins (113)
	0.05	PC,UV	Van Duuren (532)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Benzo(a)pyrene	0.03	10	0.6	16,667
	0.03	10	0.6	16,667
	0.005	1,000	0.08	1.25×10^7
	0.04	10	0.6	16,667
	0.027	10	0.4	25,000
Benzo(e)pyrene	0.01	10	0.16	62,500
	Q	10	---	---
Indeno (1:2:3-c:d) pyrene	0.02	10	0.32	31,250
1-Methyl pyrene	Q	10	---	---
4-Methyl pyrene	0.05	1,000	0.79	1.27×10^6
Styrene	10	10	158	63
o-Methylstyrene	1.0	10	16	625
m-Methylstyrene	2	10	32	313
3,4-bis-Trimethylsilyloxystyrene	Q	10	---	---
Toluene	80	10	1,270	7.9
	46	10	730	14
	80	10	1,270	8
2-Ethyltoluene	1.0	10	16	625

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Benzo(a)pyrene	0.03	GC	Chakraborty (91)
	0.03	GLC	Ayres (21)
	0.005	PC,UV	Van Duuren (532)
	0.04	GCECD	Robb (449)
	0.027	GCFID	Rathkamp (441)
Benzo(e)pyrene	0.01	GC	Chakraborty (91)
	Q	GCECD	Robb (449)
Indeno (1:2:3-c:d) pyrene	0.02	GLC	Ayres (21)
1-Methyl pyrene	Q	GCECD	Robb (449)
4-Methyl pyrene	0.05	PC,UV	Van Duuren (532)
Styrene	10	GCFID	Grob (186)
o-Methylstyrene	1.0	GCFID	Grob (186)
m-Methylstyrene	2	GCFID	Grob (186)
3,4-bis-Trimethylsilyloxystyrene	Q	GLC,UV,IR	Leach (292)
Toluene	80	GCFID	Grob (186,185,184)
	46	GC,IR	Johnstone (246)
	80	GC,IR	Spears (503)
2-Ethyltoluene	1.0	GCFID	Grob (186)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
3-Ethyltoluene	3	10	48	208
	5	10	79	127
4-Ethyltoluene	2	10	32	313
	5	10	79	127
p-Isopropenyltoluene	11	10	175	57
4-Isopropyltoluene	7-14	10	111-222	90-45
	11	10	175	57
p-Xylene	<10	10	<158	<63
m-Xylene	16	10	254	39
	30	10	476	21
	20-48	10	317-762	32-13
o-Xylene	6	10	95	105
	22	10	349	29
	10	10	158	63

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
3-Ethyltoluene	3	GCFID	Grob (186)
	5	GC	Cook (115)
4-Ethyltoluene	2	GCFID	Grob (186)
	5	GC	Cook (115)
p-Isopropenyltoluene	11	GC,IR	Johnstone (246)
4-Isopropyltoluene	7-14	GC,IR	Johnstone (246)
	11	GC,IR	Spears (503)
p-Xylene	<10	GCFID	Grob (186)
m-Xylene	16	GCFID	Grob (186)
	30	GC,IR	Spears (503)
	20-48	GC,IR	Johnstone (246)
o-Xylene	6	GCFID	Grob (186)
	22	GC,IR	Spears (503)
	10	GC	Cook (115)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Phenols				
Catechol	49-228	1,000	778-3,618	1,285-276
	500	---	7,936	---
4-Vinylcatechol	Q	10	---	---
o-Cresol	20-25	10	317-397	32-25
m- + p-Cresol	43-61	10	682-968	15-10
Eugenol	4	10	63	159
Isoeugenol	15	10	238	42
Hydroquinone	90	---	1,428	---
Myristicin (5-Methoxysafrole)	0.5	0.1	8	12.5
alpha-Naphthol	0.3	1,000	5	2×10^5
beta-Naphthol	0.5	1,000	8	1.25×10^5
Phenol	76-110	10	1,206-1,746	8.3-5.7
	83-121	0.1	1,317-1,921	0.08-0.05
	95-202	0.1	1,508-3,206	0.07-0.03
o-Ethylphenol + o-Methoxyphenol	1-15	10	16-238	625-42
m- + p-Ethylphenol	10-30	10	158-476	63-21
2,4 + 2,5-DiMePhenol	14-21	10	222-333	45-30
2,4,5, + 2,3,5,-TriMePhenol	10	10	158	63
2,6-DiMePhenol	20-45	10	317-714	32-14
Resorcinol	10	---	158	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Phenols			
Catechol	49-228	TLC,C	Kallianos (252)
	500	NMG	Kato (Cited in 573)
4-Vinylcatechol	Q	GLC,UV,IR	Leach (292)
o-Cresol	20-25	GC	Spears (501)
m- + p-Cresol	43-61	GC	Spears (501)
Eugenol	4	GC	Rodgman (453)
Isoeugenol	15	GC	Rodgman (453)
Hydroquinone	90	NMG	Kato (Cited in 573)
Myristicin (5-Methoxysafrole)	0.5	GC,IR,UV,MS	Schmeltz (479)
alpha-Naphthol	0.3	CC,UV	Commins (114)
beta-Naphthol	0.5	CC,UV	Commins (114)
Phenol	76-110	GC	Spears (501)
	83-121	MS	Hoffmann (226)
	95-202	MS	Rayburn (442)
o-Ethylphenol + o-Methoxyphenol	1-15	GCFID	Crouse (120)
m- + p-Ethylphenol	10-30	GCFID	Crouse (120)
2,4 + 2,5-DiMePhenol	14-21	GC	Spears (501)
2,4,5, + 2,3,5,-TriMePhenol	10	GCFID	Crouse (120)
2,6-DiMePhenol	20-45	GCFID	Crouse (120)
Resorcinol	10	NMG	Kato (Cited in 573)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Nitriles				
Acetonitrile	140	10	2,222	4.5
	1,000	0.1	15,870	0.0063
	114[a]	10	1,816	5.5
Acrylonitrile	10	10	158	63
Methacrylonitrile	3	10	48	208
Allylnitrile	Q	0.1	---	---
9-Anthronitrile	Q	0.1	---	---
Butyronitrile	5	10	79	127
Isobutyronitrile	8	10	127	79
n-Capronitrile	1	10	16	625
Isocapronitrile	t	10	---	---
Cinnamonitrile	Q	0.1	---	---
Hydrocinnamonitrile	Q	0.1	---	---
Crontonitrile	3	10	48	208
	3.2[a]	10	51	196

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)
AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Nitriles			
Acetonitrile	140	GCFID	Grob (186,185,184)
	1000	GC,MS	Campbell (81)
	114[a]	GC	Terrell (519)
Acrylonitrile	10	GCFID	Grob (186,185,184)
Methacrylonitrile	3	GCFID	Grob (186,185)
Allylnitrile	Q	MS	Grob (188)
9-Anthronitrile	Q	MS	Brown (70)
Butyronitrile	5	GCFID	Grob (186)
Isobutyronitrile	8	GCFID	Grob (185,184)
n-Capronitrile	1.0	GCFID	Grob (186)
Isocapronitrile	t	GCFID	Grob (186)
Cinnamonitrile	Q	GC,MS	Kaburaki (250)
Hydrocinnamonitrile	Q	GC,MS	Kaburaki (250)
Crotonitrile	3	GCFID	Grob (186)
	3.2[a]	GLC	Newsome (380)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (ug)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Hydrogen cyanide	300-500	1,000	4,762-7,936	210-126
	300	0.1	4,762	0.02
	400	10	6,348	1.6
	130-149	1,000	2,063-2,365	485-423
	338	26,000	5,364	4,847
	280[a]	---	4,444	---
	184[a]	1,000	2,920	342
Cyanogen	Q	---	---	---
Nicotinonitrile	3-10	10	48-158	208-63
Phenylacetonitrile	Q	0.1	---	---
Propionitrile	30	10	476	21
n-Valeronitrile	2	10	32	313
Isovaleronitrile	t	10	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Hydrogen cyanide	300-500	C	Guerin (197a)
	300	MS	Keith (258)
	400	GC,IR	Spears (503)
	130-149	C	Nall (360)
	338	POT	Vickroy (538)
	280[a]	POT	Mattina (323)
	184[a]	C	Terrell (519)
Cyanogen	Q	NMG	Johnstone (243)
Nicotinonitrile	3-10	GC	Kaburaki (249)
Phenylacetonitrile	Q	GC,MS	Kaburaki (250)
Propionitrile	30	GCFID	Grob (186,185,184)
n-Valeronitrile	2	GCFID	Grob (186)
Isovaleronitrile	t	GCFID	Grob (186)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Sulfur Containing Compounds				
Carbon Monosulfide	Q	0.1	---	---
Carbon Disulfide	2	10	32	313
Carbonylsulfide	35	10	556	18
Dimethylsulfide	Q	0.1	---	---
Diemthyldisulfide	Q	0.1	---	---
Ethylmercaptan	Q	0.1	---	---
Hydrogen Sulfide	85	10	1,349	7
	39-49	32,000	619-778	51,696-41,131
	36[a]	1,000	571	1,751
Methylmercaptan	Q	0.1	---	---
Methylthionitrite	6	0.1	95	17
Sulfur Dioxide	3	10	48	208
	0.8[a]	10	13	769
Thiocyanic Acid	Q	---	---	---
Thiocyanogen	Q	---	---	---
Thiophene (Divinylene Sulfide)	2	10	32	313

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Sulfur Containing Compounds			
Carbon Monosulfide	Q	MS,IR	Osborne (399)
Carbon Disulfide	2	GCFPD	Horton (229a)
Carbonylsulfide	35	GCFPD	Horton (229a)
Dimethylsulfide	Q	GC,IR,MS	Philippe (419)
Dimethyldisulfide	Q	GC,MS	Mokhnachev (342)
Ethylmercaptan	Q	GC,MS	Mokhnachev (342)
Hydrogen Sulfide	85	GCFPD	Horton (229a)
	39-49	POT	Morie (350)
	36[a]	C	Terrell (519)
Methylmercaptan	Q	MS	Grob (186)
Methylthionitrite	6	IR,MS	Philippe (424)
Sulfur Dioxide	3	GCFPD	Horton (229a)
	0.8[a]	GLC	Newsome (379)
Thiocyanic Acid	Q	GRAV	Bentley (46)
Thiocyanogen	Q	GRAV	Bentley (46)
Thiophene (Divinylene Sulfide)	2	GCFID	Grob (186,185,184)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Amines				
Allyamine	Q	0.1	---	---
n-Amylamine	Q	0.1	---	---
Isoamylamine	3.2[a]	0.1	51	1.96
Aniline	2	0.1	32	3.1
n-Butylamine	2.4[a]	0.1	38	2.6
2-Aminobutane	Q	0.1	---	---
Isobutylamine	2.4[a]	0.1	38	2.6
Ethylamine	t	0.1	---	---
	8	0.1	127	0.8
Diethylamine	Q	0.1	---	---
Methylethylamine	1.6[a]	0.1	25	4
β-Phenylethylamine	8.3[f]	0.1	132	.76
Methyl-β-phenylethylamine	1.2[f]	0.1	19	5.3
n-Hexylamine	Q	0.1	---	---
Hydrazine	0.032	10	0.5	20,000

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Amines			
Allyamine	Q	GC,MS	Pailer (402)
n-Amylamine	Q	GC,MS	Pailer (402)
Isoamylamine	3.2[a]	MP,IR,MS	Neurath (370)
Aniline	2	GC,MS	Pailer (402)
n-Butylamine	2.4[a]	MP,IR,MS	Neurath (370)
2-Aminobutane	Q	GC,MS	Pailer (402)
Isobutylamine	2.4[a]	MP,IR,MS	Neurath (370)
Ethylamine	t	IR,MS	Osborne (399)
	8	MP,IR,MS	Neurath (370)
Diethylamine	Q	GC,MS	Pailer (402)
Methylethylamine	1.6[a]	MP,IR,MS	Neurath (370)
β-Phenylethylamine	8.3[f]	MP,IR,MS	Neurath (370)
Methyl-β-phenylethylamine	1.2[f]	MP,IR,MS	Neurath (370)
n-Hexylamine	Q	GC,MS	Pailer (402)
Hydrazine	0.032	GCFID	Hoffmann (221)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Methylamine	16[a]	0.1	254	0.4
Dimethylamine	8[a]	0.1	127	0.8
Trimethylamine	Q	---	---	---
n-Butyl-methylamine	Q	0.1	---	---
alpha-Naphthylamine	0.025	10	0.4	25,000
beta-Naphthylamine	0.025	10	0.4	25,000
Methylethylnitrosamine	0.03	10	0.5	20,000
Diethylnitrosamine	<0.005	10	<0.08	<125,000
n-Dimethylnitrosamine	0.084	10	1.3	7,692
	0-0.140	10	0-2.2	>4,545
N-Phenyl-4-isopropylphenylamine	Q	0.1	---	---
n-Propylamine	1.6[a]	0.1	25	4
Di-n-propylamine	Q	0.1	---	---
Isopropylamine	Q	0.1	---	---
n-Propyl-isopropylamine	Q	0.1	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Methylamine	16[a]	MP,IR,MS	Neurath (370)
Dimethylamine	8[a]	MP,IR,MS	Neurath (370)
Trimethylamine	Q	PC	Johnstone (243)
n-Butyl-methylamine	Q	GC,MS	Pailer (402)
alpha-Naphthylamine	0.025	GC	Masuda (321)
beta-Naphthylamine	0.025	GC	Masuda (321)
Methylethylnitrosamine	0.03	GCFID	Hoffmann (221)
Diethylnitrosamine	<0.005	GCFID	Hoffmann (221)
n-Dimethylnitrosamine	0.084	GCFID	Hoffmann (221)
	0-0.140	GC	Rhoades (445)
N-Phenyl-4-isopropylphenylamine	Q	GC,IR,MS	Miller (336)
n-Propylamine	1.6[a]	MP,IR,MS	Neurath (370)
Di-n-propylamine	Q	GC,MS	Pailer (402)
Isopropylamine	Q	GC,MS	Pailer (402)
n-Propyl-isopropylamine	Q	GC,MS	Pailer (402)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Carboxylic Acids				
Acetic Acid	370	10	5,872	1.7
	722	10	11,458	0.9
	650-1,030	10	10,316-16,346	1-0.6
	117-322	10	1,857-5,110	5.4-2.0
Adipic Acid	6	10	95	105
n-Butyric Acid	10-50	10	158-794	63.3-12.6
	12	10	190	52.6
Isobutyric Acid	10-25	10	158-397	63.3-25.2
	10	10	158	63.3
(n) Caproic Acid	5-12	10	79-190	127-53
Isocaproic Acid	5-20	10	79-317	127-31.5
Capronic Acid	Q	10	---	---
Caprylic Acid	Q	10	---	---
Formic Acid	280-420	10	4,444-6,665	2.3-1.5
	48-94	10	762-1,492	.0013-6.7
	600	10	9,522	1.1
Furoic Acid	30-140	10	476-2,222	21-4.5
Glutaric Acid	30	10	476	21

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)
AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Carboxylic Acids			
Acetic Acid	370	GCFID	Morie (351)
	722	GCFID	Stedman (508)
	650-1030	PC,CC,GC	Buyske (78)
	117-322	GCTCD	Oakley (393)
Adipic Acid	6	GC	Quin (438)
n-Butyric Acid	10-50	GC,IR,UV	Stedman (509)
	12	GC	Morie (351)
Isobutyric Acid	10-25	GC,IR,UV	Stedman (509)
	10	GC	Morie (351)
(n) Caproic Acid	5-12	GC,IR,UV	Stedman (509)
Isocaproic Acid	5-20	GC,IR,UV	Stedman (509)
Capronic Acid	Q	GC	Mokhnachev (343)
Caprylic Acid	Q	GC	Mokhnachev (343)
Formic Acid	280-420	PC,CC,GC	Buyske (78)
	48-94	GCTCD	Oakley (393)
	600	GC,IR	Spears (503)
Furoic Acid	30-140	GC	Quin (438)
Glutaric Acid	30	GC	Quin (438)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Glycolic Acid	50-300	10	794-4,762	12.6-2.1
(n) Heptylic Acid	12-50	10	190-794	53-12.6
Lactic Acid	50-300	10	794-4,762	12.6-2.1
Lauric Acid	Q	10	---	---
Linoleic Acid	50-150	0.1	794-2,381	0.13-0.04
Linolenic Acid	50-300	0.1	794-4,762	0.04-0.02
Levulinic Acid	20-70	10	317-1,111	32-9
Malic Acid	60	10	952	11
Malonic Acid	90	10	1,428	7
Margaric Acid	Q	10	---	---
Myristic Acid	Q	10	---	---
Oleic Acid	20-100	0.1	317-1,587	0.3-0.06
Oxalic Acid	40-90	10	635-1,428	16-7

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Glycolic Acid	50-300	GC	Quin (438)
(n) Heptylic Acid	12-50	GC,IR,UV	Stedman (509)
Lactic Acid	50-300	GC	Quin (438)
Lauric Acid	Q	GC	Mokhnachev (343)
Linoleic Acid	50-150	GCFID,IR,MS	Hoffmann (225)
Linolenic Acid	50-300	GCFID,IR,MS	Hoffmann (225)
Levulinic Acid	20-70	GC	Quin (438)
Malic Acid	60	GC	Quin (438)
Malonic Acid	90	GC	Quin (438)
Margaric Acid	Q	GC	Mokhnachev (343)
Myristic Acid	Q	GC	Mokhnachev (343)
Oleic Acid	20-100	GCFID,IR,MS	Hoffmann (225)
Oxalic Acid	40-90	GC	Quin (438)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Palmitic Acid	50-300	0.1	794-4,762	0.04-0.02
Pelargonic Acid	Q	10	---	---
Pentadecanoic Acid	Q	10	---	---
Phthalic Acid	40	10	635	16
Propionic Acid	300	10	4,762	2.1
	110-230	10	1,746-3,650	6-3
Succinic Acid	100-250	10	1,587-3,968	6.3-2.5
Stearic Acid	30-90	0.1	476-1,428	0.2-0.07
Tridecanoic Acid	Q	10	---	---
Undeacanoic Acid	Q	10	---	---
Valeric Acid	7-50	10	111-794	90-12.6
Isovaleric Acid	15	10	238	42
	10	10	158	63
beta-Methylvaleric Acid	20-40	10	317-635	32-16

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Palmitic Acid	50-300	GCFID,IR,MS	Hoffmann (225)
Pelargonic Acid	Q	GC	Mokhnachev (343)
Pentadecanoic Acid	Q	GC	Mokhnachev (343)
Phthalic Acid	40	GC	Quin (438)
Propionic Acid	300	GC,IR	Spears (503)
	110-230	PC,CC,GC	Buyske (78)
Succinic Acid	100-250	GC	Quin (438)
Stearic Acid	30-90	GCFID,IR,MS	Hoffmann (225)
Tridecanoic Acid	Q	GC	Mokhnachev (343)
Undecanoic Acid	Q	GC	Mokhnachev (343)
Valeric Acid	7-50	GC,IR,UV	Stedman (509)
Isovaleric Acid	15	GC,IR,UV	Stedman (509)
	10	GCFID	Morie (351)
beta-Methylvaleric Acid	20-40	GC,IR,UV	Stedman (509)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Inorganics				
Ammonia	53-103[c]	---	844-1,644	---
	60-330	---	952-5,237	---
	10	10	158	63
Antimony	49[f]	1000	776	1,289
Argon	5000	0.1	79,350	0.001
Arsenic	5.6[f]	1000	89	11,236
	13-19[f]	10,000	200-300	50,000-33,333
Bromine	9.3[f]	1000	148	6,757
Cadmium	0.1-0.25	4.58×10^{-3}	1.6-4.0	2.9-1.1
	0.8	1000	12.7	78,740
	0.1	4	1.6	2,500
Chromium	0.005-0.02	2.13×10^{-3}	0.08-0.32	27-6.7
	0.017[f]	1000	0.27	3,700,000
Cobalt	0.466[f]	1000	7.4	135,135
Copper	0.05-0.12	2.62×10^{-3}	0.8-1.9	3.3-1.4
Hydrogen	700	0.1	11,100	.009
	275[d]	0.1	4,000	.025
	390[d]	10	5,500	1.8

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Inorganics			
Ammonia	53-103[c]	A	Bradford (65)
	60-330	NMG	Neurath (366)
	10	GCTCD	Newsome (378)
Antimony	49[f]	NAA	Nadkarni (358)
Argon	5000	MS	Keith (258)
Arsenic	5.6[f]	NAA	Nadkarni (358)
	13-19[f]	SPF	Williams (567)
Bromine	9.3[f]	NAA	Nadkarni (358)
Cadmium	0.1-0.25	SSMS	Guerin (197)
	0.8	C	Nandi (359)
	0.1	AAS	Menden (332)
Chromium	0.005-0.02	SSMS	Guerin (197)
	0.017[f]	NAA	Nadkarni (358)
Cobalt	0.466[f]	NAA	Nadkarni (358)
Copper	0.05-0.12	SSMS	Guerin (197)
Hydrogen	700	GC,MS	Keith (258)
	275[d]	GCTCD,MS	Newsome (378)
	390[d]	GC	Lakritz (281)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Iron	150[f]	1000	2,400	417
Lanthanum	2.1[f]	1000	33	30,303
Lead	0.075-0.175	8.47×10^{-3}	1.2-2.8	7-3
Mercury	0.001-0.005	4.11×10^{-3}	0.016-0.08	257-51
	22.4[f]	1000	350	2,857
Nickel	0.025-0.075	2.41×10^{-3}	0.4-1.4	6-1.7
	0.02-0.08	10	0.32-1.3	31,250-7,692
Nitric Oxide	350[a]	1000	5,586	179
	100-600	---	1,587-9,522	---
	148-450	100	2,348-7.142	43-14
	310[a]	1000	4,900	204
Nitrogen	2.2×10^{5}[d]	0.1	3.4×10^{6}	2.9×10^{-5}
	$1.7\text{-}2.2 \times 10^{5}$[d]	0.1	$2.7\text{-}3.6 \times 10^{6}$	$3.7 \times 10^{-5}\text{-}2.8 \times 10^{-5}$
Nitrogen Dioxide	45-580	1000	710-9,200	1,408-107
	32[f]	---	510	---
	12[a]	1000	190	5,263
Nitrous Oxide	30-40	1000	476-635	2,101-1,574
	30-44	---	476-698	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)
AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Iron	150[f]	NAA	Nadkarni (358)
Lanthanum	2.1[f]	NAA	Nadkarni (358)
Lead	0.075-0.175	SSMS	Guerin (197)
Mercury	0.001-0.005	FLS	Guerin (197)
	22.4[f]	NAA	Nadkarni (358)
Nickel	0.025-0.075	SSMS	Guerin (197)
	0.02-0.08	AAS	Menden (332)
Nitric Oxide	350[a]	SPF	Sloan (493)
	100-600	NMG	Neurath (366)
	148-450	CLUM	Neurath (369)
	310[a]	C	Norman (386)
Nitrogen	2.2×10^{5}[d]	GC,MS,IR	Keith (258)
	$1.7\text{-}2.2 \times 10^{5}$[d]	GC,MS,IR	Newsome (378)
Nitrogen Dioxide	45-580	IR,UV	Smith (496)
	32[f]	NMG	Bokhoven (59)
	12[a]	SPF	Sloan (493)
Nitrous Oxide	30-40	IR	Philippe (420)
	30-44	NMG	Neurath (366)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Mixture NO + NO_2	650-700	1,000	10,316-11,100	97-90
	100[f*]	---	1,600	---
Oxygen	49,000[d]	0.1	7.9×10^5	1.3×10^{-4}
	57,000[d]	0.1	9.5×10^5	1.1×10^{-4}
	44,000[d]	10	7.3×10^5	.014
	53,000[e]	10	8.7×10^5	.011
Polonium-210	0.042pCi	0.8 DPH	---	---
	0.45 pCi	= background	---	---
Scandium	0.6[f]	1,000	9.5	105,263
Selenium	2.4	1,000	38	26,316
Silver	0.37	1,000	5.9	1.7×10^5
Water	6,000-7,000	---	5.7×10^4-1.1×10^5	---
	5,800	0.1	9.2×10^4	0.001
	8,600	1×10^6	1.4×10^5	7,000
Zinc	0.2 to 1.0	2.66×10^{-3}	3-16	0.9-0.06
	22[f]	1,000	350[f]	2,857

† Based on uniform distribution after smoking one cigarette.

* Based on molecular weight of NO_2 assuming NO is converted to NO_2.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Mixture $NO+NO_2$	650-700	IR,UV	Westcott (558)
	100[f] *	NMG	Bokhoven (59)
Oxygen	49,000[d]	GC,MS	Keith (258)
	57,000[d]	GCTCD,MS	Newsome (378)
	44,000[d]	GC	Lakritz (281)
	53,000[e]	GC	Terrell (519)
Polonium - 210	0.042pCi	Gas Flow Proportional Counter	Kelly (260)
	0.45pCi		Little (308)
Scandium	0.6[f]	NAA	Nadkarni (358)
Selenium	2.4	NAA	Nadkarni (358)
Silver	0.37	NAA	Nadkarni (358)
Water	6000-7000	Karl Fisher	Holmes (227)
	5800	GC,MS	Keith (258)
	8600	A	Seehofer (488)
Zinc	0.2-1.0	SSMS	Guerin (197)
	22[f]	NAA	Nadkarni (358)

* Based on molecular weight of NO_2 assuming NO is converted to NO_2.

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (ug)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Heterocyclic N				
Dibenz(a,h)acridine	0.0001	1,000	0.00016	6.25×10^9
Dibenz(a,j)acridine	0.003-0.01	1,000	0.048-0.159	2.1×10^7-6.3×10^7
Carbazole (Dibenzopyrrole)	0.7	0.1	11.1	9
	t	10	---	---
	1.0	0.1	15.9	6.29
7-H-Dibenzo(a,g)carbazole	0.00007	10	0.001	1×10^7
Dibenz(c,g)carbazole	0.0007	1,000	0.011	9.1×10^7
9-Ethylcarbazole	0.006	10	0.095	105,263
1-Me-Carbazole	0.23	0.1	3.65	27
	0.2	0.1	3.17	32
2- + 3-Methyl Carbazole	0.19	0.1	3.02	33
4-Methyl Carbazole	0.098	0.1	1.56	64
9-Me-Carbazole	0.1	10	1.59	6,289
1,9-Di-Me-Carbazole	0.01	10	0.159	62,893
2,9 and 3,9-DiMe-Carbazole	0.02	10	0.317	31,546
4,9-DiMe-Carbazole	0.006	10	0.095	105,263

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)
AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Heterocyclic N			
Dibenz(a,h)acridine	0.0001	PC,FS,UV	Van Duuren (533)
Dibenz(a,j)acridine	0.003-0.01	PC,FS,UV	Van Duuren (533)
Carbazole (Dibenzopyrrole)	0.7	CC,IR,UV,NMR,MS	Rodgman (451)
	t	GC,IR,UV	Schmeltz (481)
	1.0	GC,MS	Hoffmann (223)
7-H-Dibenzo(a,g)carbazole	0.00007	GC,IR	Van Duuren (534)
Dibenz(c,g)carbazole	0.0007	PC,FS,UV	Van Duuren (533)
9-Ethylcarbazole	0.006	GCFID	Hoffmann (222)
1-Me-Carbazole	0.23	GCFID,MS	Hoffmann (223)
	0.2	IR,UV,NMR,MS	Rodgman (451)
2- + 3-Methyl Carbazole	0.19	GCFID,MS	Hoffmann (223)
4-Methyl Carbazole	0.098	GCFID,MS	Hoffmann (223)
9-Me-Carbazole	0.1	GCFID	Hoffmann (222)
1,9-Di-Me-Carbazole	0.01	GCFID	Hoffmann (222)
2,9 and 3,9-DiMe-Carbazole	0.02	GCFID	Hoffmann (222)
4,9-DiMe-Carbazole	0.006	GCFID	Hoffmann (222)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Indole	14	10	222	45
	17.4	10	276	36
3-Ethylindole	4	1,000	63	15,873
	4	10	63	159
1-Methylindole	0.39	10	6.19	1,616
Skatole (3-Methylindole)	14	10	222	45
	12.9	10	205	49
1,3-Dimethylindole	0.25	10	3.97	2,519
Dimethylindoles	0.03	1,000	0.476	2.1×10^6
	0.03	10	0.476	21,008
Di-Me-Indole	1	0.1	15.8	6.3
Tri-Me-Indole	0.5	0.1	7.9	12.7
3-Phenylindole	0.31	0.1	4.92	20.3
3-N-Propylindole	0.2	1,000	3.2	312,500
	0.2	10	3.2	3,125
Harmane + Norharmane	15-20	1,000	238-317	4,202-3,155
Piperidine	8.1[a]	0.1	114.3	0.9

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Indole	14	GCFID	Hoffmann (224)
	17.4	GCFID	Rathkamp (441)
3-Ethylindole	4	PC,SPF	Buyske (77)
	4	GCFID	Hoffmann (224)
1-Methylindole	0.39	GCFID	Rathkamp (441)
Skatole (3-Methylindole)	14	GCFID	Hoffmann (224)
	12.9	GCFID	Rathkamp (441)
1,3-Dimethylindole	0.25	GCFID	Rathkamp (441)
Dimethylindoles	0.03	PC,SPF	Buyske (77)
	0.03	GCFID	Hoffmann (224)
Di-Me-Indole	1	CC,IR,UV,NMR,MS	Rodgman (451)
Tri-Me-Indole	0.5	CC,IR,UV,NMR,MS	Rodgman (451)
3-Phenylindole	0.31	GCFID,MS	Hoffmann (223)
3-N-Propylindole	0.2	PC,SPF	Buyske (77)
	0.2	GCFID	Hoffmann (224)
Harmane + Norharmane	15-20	UV,IR,FS	Poindexter (429)
Piperidine	8.1[a]	MP,IR,MS	Neurath (370)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Δ^3-Piperidine	0.76[f]	0.1	12.1	8.3
Anabasine (Neonicotine)	3-11	10	48-175	208-57
Anatabine	14	10	222	45
Pyridine	30-140	10	476-2222	21-4.5
	20[a]	1,000	317	3,155
3-Methylaminopyridine	0.62[f]	0.1	98	1.02
Quinoline (Benzo(b)pyridine)	4-15	10	63-238	159-42
3-Cyanopyridine	Q	10	---	---
2-Ethylpyridine	Q	10	---	---
3-Ethylpyridine	1-9	10	16-140	625-71
	2-12	10	32-190	313-53
2-Methylpyridine (α-Picolin)	31	10	490	20
3-Methylpyridine	Q	10	---	---
4-Methylpyridine	51	10	810	12
	3-50	10	48-800	208-13
2- + 4-Methylpyridine	20-50	10	300-800	33-13

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)
AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Δ^3-Piperidine	0.76[f]	MP,IR,MS	Neurath (370)
Anabasine (Neonicotine)	3-11	GCTCD,GCFID	Schmeltz (480)
Anatabine	14	PC,GC,UV	Quin (437)
Pyridine	30-140	GCTCD,GCFID	Schmeltz (480)
	20[a]	C	Waltz (546)
3-Methylaminopyridine	0.62[f]	UV,TLC,IR,MS	Neurath (370)
Quinoline (Benzo(b)pyridine)	4-15	GC	Kaburaki (249)
3-Cyanopyridine	Q	GC	Artho (14)
2-Ethylpyridine	Q	GC	Artho (14)
3-Ethylpyridine	1-9	GCTCD,GCFID	Schmeltz (480)
	2-12	GC	Kaburaki (249)
2-Methylpyridine (α-Picolin)	31	GCTCD,GCFID	Schmeltz (480)
3-Methylpyridine	Q	GC	Artho (14)
4-Methylpyridine	51	GC,IR	Schmeltz (480)
	3-50	GC	Kaburaki (249)
2- ± 4-Methylpyridine	20-50	GCTCD,GCFID	Schmeltz (480)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT

(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
3- + 4-Methylpyridine	3-50	10	50-800	200-13
2,3-Dimethylpyridine	0.5	10	8	1,250
	0.5	10	8	1,250
2,4-Dimethylpyridine	Q	10	---	---
2,4- + 2,5-Dimethylpyridine	2-15	10	30-240	333-42
	2-15	10	30-240	333-42
2,5-Dimethylpyridine (2,5-Lutidine)	2	10	30	333
	2	10	30	333
2,6-Dimethylpyridine (2,6-Lutidine)	1.5	10	24	417
3,4-Dimethylpyridine	Q	10	---	---
3,5-Dimethylpyridine	4-25	10	60-400	167-25
	Q	10	---	---
2-Phenylpyridine	Q	0.1	---	---
3-Phenylpyridine	Q	0.1	---	---
Nicotine	200-3,500	1,000	3,000-55,000	333-18
	3,400	0.1	54,000	0.002
	4,900	0.1	78,000	0.001

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (ug)	Method of Analysis	Reference
3- + 4-Methylpyridine	3-50	GCTCD,GCFID	Schmeltz (480)
2,3-Dimethylpyridine	0.5	GCTCD,GCFID	Schmeltz (480)
	0.5	GC	Kaburaki (249)
2,4-Dimethylpyridine	Q	GC	Artho (14)
2,4- + 2,5-Dimethylpyridine	2-15	GCTCD,GCFID	Schmeltz (480)
	2-15	GC	Kaburaki (249)
2,5-Dimethylpyridine (2,5-Lutidine)	2	GCTCD,GCFID	Schmeltz (480)
	2	GC	Kaburaki (249)
2,6-Dimethylpyridine (2,6-Lutidine)	1.5	GCTCD,GCFID	Schmeltz (480)
3,4-Dimethylpyridine	Q	GCTCD,GCFID	Schmeltz (480)
3,5-Dimethylpyridine	4-25	GC	Kaburaki (249)
	Q	GCTCD,GCFID	Schmeltz (480)
2-Phenylpyridine	Q	GC,MS	Neurath (368)
3-Phenylpyridine	Q	GC,MS	Neurath (368)
Nicotine	200-3,500	UV	FTC (170)
	3,400	GC,MS	Enzell (154)
	4,900	GC,MS	Enzell (155)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Nornicotine	1	10	16	625
Nitrosonornicotine	0.137	10	217	46
2,3-Dipyridyl (Pyridylpyridine)	7-20	10	110-320	91-31
	7-20	10	110-320	91-31
3-Vinylpyridine	28	10	440	23
Pyrocoll	1	0.1	16	6.25
Pyrrole	t	10	---	---
N-Methylpyrrole	Q	0.1	---	---
Pyrrolidine	24[a]	0.1	380	0.26
2-Methylpyrrolidine	0.48[a]	0.1	7.6	13.2
Cotinine	60	10	950	10.5
2,3- + 2,4,6-Collidine	2	10	30	333
Δ^3-Pyrroline	Q	0.1	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Nornicotine	1	GC,UV	Quin (436)
Nitrosonornicotine	0.137	GCFID	Hoffmann (221)
2,3-Dipyridyl (Pyridylpyridine)	7-20	GCFID	Schmeltz (480)
	7-20	PC,GC,UV	Quin (437)
3-Vinylpyridine	28	GCFID	Schmeltz (480)
Pyrocoll	1	CC,IR,UV,NMR,MS	Rodgman (451)
Pyrrole	t	GCFID	Schmeltz (480)
N-Methylpyrrole	Q	MS	Grob (188)
Pyrrolidine	24[a]	MP,IR,MS	Neurath (370)
2-Methylpyrrolidine	0.48[a]	MP,IR,MS	Neurath (370)
Cotinine	60	PC,GC,UV	Quin (437)
2,3- + 2,4,6-Collidine	2	GCFID	Schmeltz (480)
Δ^3-Pyrroline	Q	GC,MS	Pailer (402)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Miscellaneous				
Acetamide	38-56	0.1	603-889	0.17-0.11
Carbon Dioxide	$4\text{-}5 \times 10^{4}$[d]	10	$6.3\text{-}7.9 \times 10^{5}$	$1.5 \times 10^{-2}\text{-}1.3 \times 10^{-2}$
	6.8×10^{4}	0.1	10.8×10^{5}	0.0009
	3.7×10^{4}[d]	---	5.9×10^{5}	---
	3.8×10^{4}[d]	10	6.0×10^{5}	0.02
	5.5×10^{4}[e]	10	8.7×10^{5}	0.01
Carbon Monoxide	9,619 - 16,032[d]	10	$1.5\text{-}2.5 \times 10^{5}$	$6.7 \times 10^{-2}\text{-}4.0 \times 10^{-2}$
	16,200	0.1	2.6×10^{5}	0.004
	15,300	10	2.4×10^{5}	0.04
	6,733[d]	---	1.1×10^{5}	---
	10,580[d]	10	1.7×10^{5}	0.06
	13,800 - 16,200[c]	1,000	$2.2\text{-}2.4 \times 10^{5}$	4.6 - 4.2
	17,000[e]	0.1	2.7×10^{5}	0.0004
	8,977[e]	10	1.4×10^{5}	0.07
Dihydroactinidiolide	Q	0.1	---	---
Ethylchloride	Q	0.1	---	---

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Miscellaneous			
Acetamide	38-56	GC,MS	Johnson (241)
Carbon Dioxide	$4.0\text{-}5.0 \times 10^4$[d]	GCTCD	Horton (229)
	6.8×10^4	GC,MS	Keith (258)
	3.7×10^4[d]	NMG	Bokhoven (59)
	3.8×10^4[d]	GC	Lakritz (281)
	5.5×10^4[e]	GC	Terrell (519)
Carbon Monoxide	9,619 to 16,032[d]	GCTCD	Horton (229)
	16,200	GC,MS	Keith (258)
	15,300	GC	Waltz (545)
	6,733[d]	NMG	Bokhoven (59)
	10,580[d]	GC	Lakritz (281)
	13,800 to 16,200[c]	IR	Collins (111)
	17,000[e]	MS,IR	Osborne (399)
	8,977[e]	GC	Terrell (519)
Dihydroactinidiolide	Q	GC,MS	Kaburaki (250)
Ethylchloride	Q	GC,MS	Grob (188), Völlmin (540)

TABLE 2-A (cont.)

ESTIMATE OF THE VOLUME OF BODY FLUID NEEDED FOR ANALYSIS OF INDIVIDUAL SMOKE COMPONENT
(BASED ON ANALYTICAL SENSITIVITY AND POSSIBLE CONCENTRATION *IN SITU*)

Component	Amount per Cig. (µg)	Estimated Sensitivity of Anal. Method (ng)	Amount in Body Fluid† (pg/gm)	Sample Size per Cig. (ml or gm)
Ethylene Oxide	5.6[c]	10	90	111
Ethyl Nitrite	Q	10	---	---
Formamide	4-27	0.1	63-430	1.59-2.3
Isopropyl Nitrite	Q	10	---	---
Methychloride	744[e]	10	12,000	0.8
	219[e]	10	3,500	0.3
	954[e]	0.1	15,000	.007
	236[e]	10	3,700	2.7
	672[f]	---	11,000	---
	200-600	10	3,000-9,500	3.3 - 1.1
	480-860[e]	1,000	7,600-14,000	132-71
Methylisocyanate	4.8[a]	0.1	76	1.3
Methylnitrite	16-468	10	250-7,400	40-1.4
	19-94	10	300-1,500	33-6.7
Propionamide	6-25	0.1	95-397	1.05-0.25

† Based on uniform distribution after smoking one cigarette.

TABLE 2-B (cont.)

AGENTS IN CIGARETTE SMOKE

Component	Amount per Cigarette (µg)	Method of Analysis	Reference
Ethylene Oxide	5.6[c]	GC	Binder (51)
Ethyl Nitrite	Q	GLC	Newsome (379)
Formamide	4-27	GC,MS	Johnson (241)
Isopropyl Nitrite	Q	GLC	Newsome (379)
Methylchloride	744[e]	GC	Carugno (87)
	219[e]	C,POT,GC	Norman (388)
	954[e]	IR,MS	Osborne (399)
	236[e]	GCTCD	Philippe (425)
	672[f]	---	PHS (434)
	200-600	GCTCD	Newsome (378)
	480-860[e]	IR	Philippe (421)
Methylisocyanate	4.8[a]	GLC,IR,MS	Philippe (422)
Methylnitrite	16-468	GC,IR	Philippe (420)
	19-94	GLC,SPF	Sloan (494)
Propionamide	6-25	GC,MS	Johnson (241)